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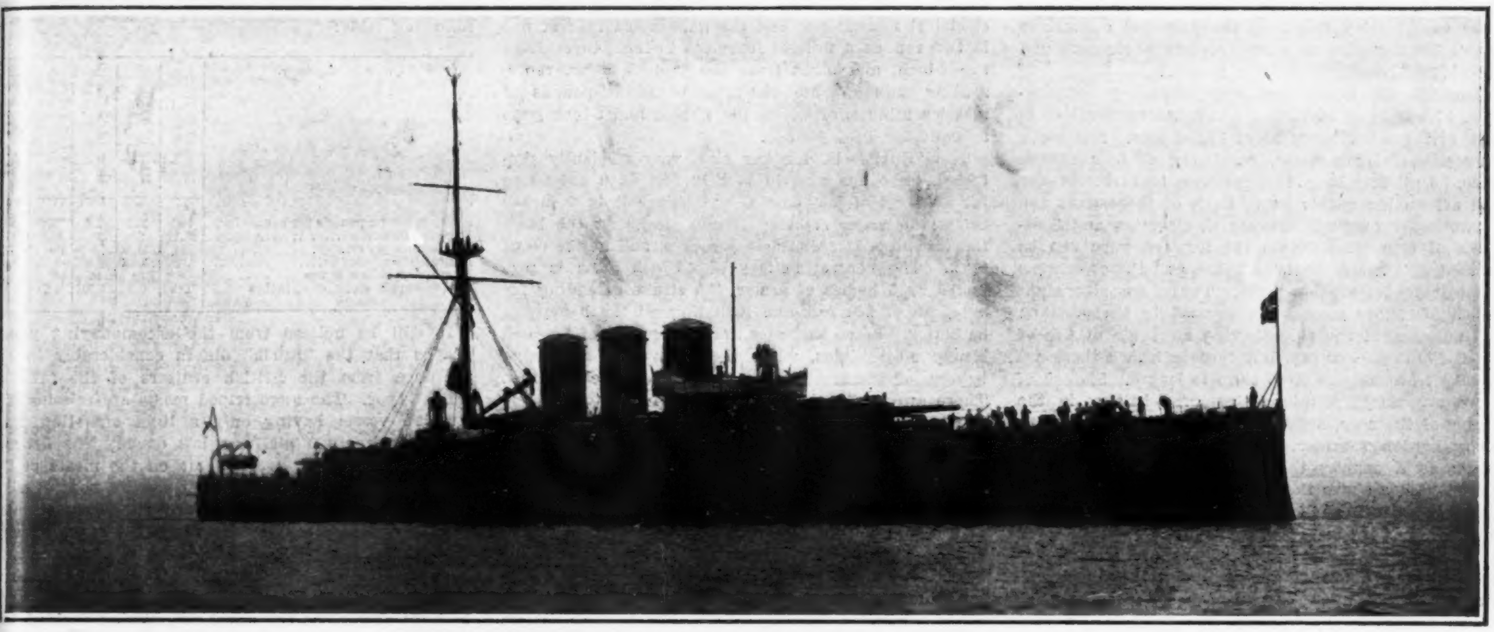
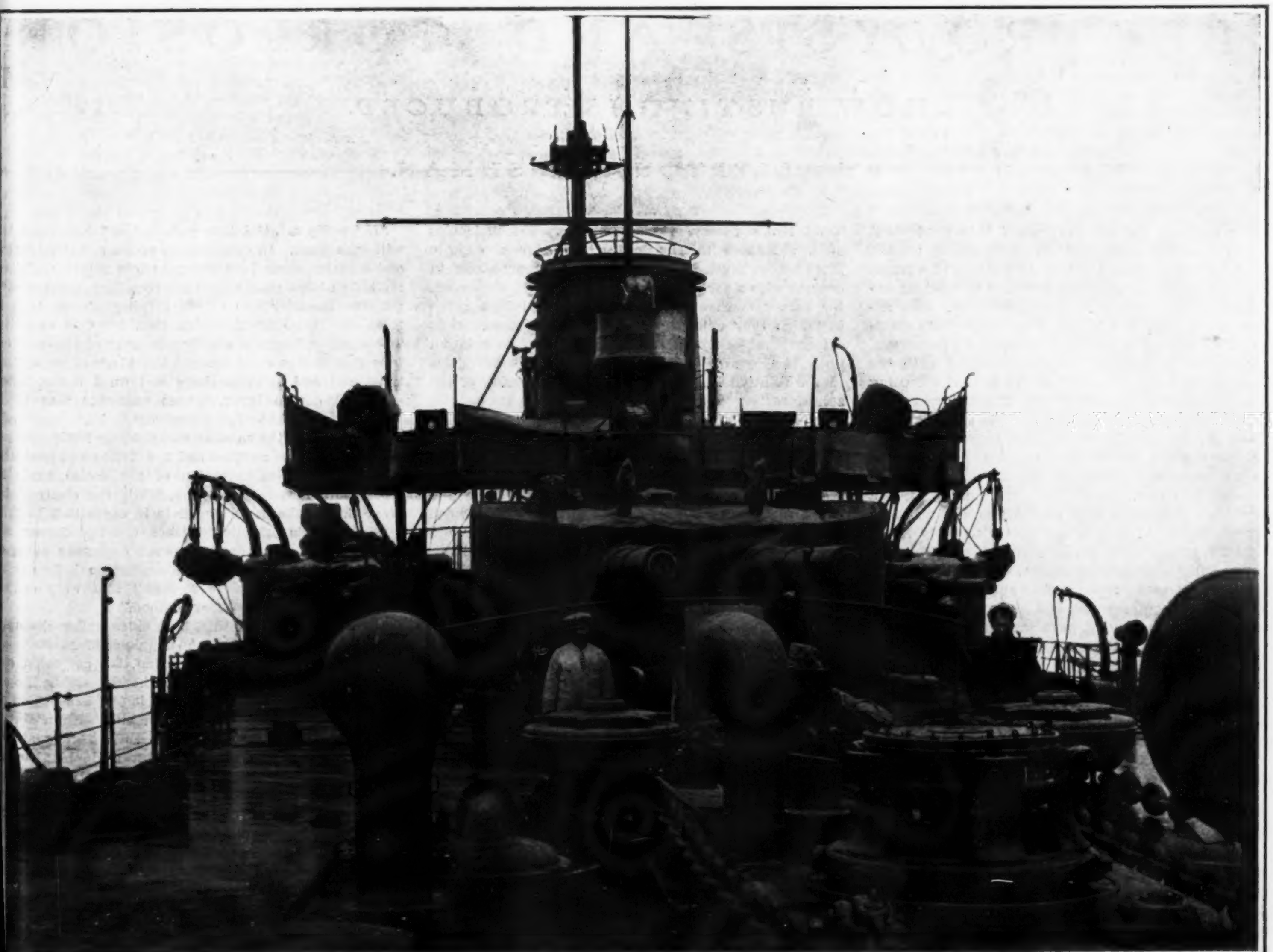


THE RUSSIAN ARMORED CRUISER "RURIK."

Length, 490 feet. **Beam,** 75 feet. **Draft,** 26 feet. **Displacement,** 15,200 tons. **Speed,** 21 knots. **Armament:** Four 10-inch; eight 8-inch; twenty 4.7-inch; twelve rapid-fire guns and two torpedo tubes. **Armor:** Main belt, 12 feet deep, 270 feet long, and 6 inches thick; protective deck, 4 inches.



FORECASTLE OF THE "RURIK" LOOKING AFT, SHOWING TWO 10-INCH GUNS IN TURRET AND TWO 8-INCH GUNS ON EITHER SIDE. THE SHORT FIRE CONTROL TOWER MAY BE SEEN IMMEDIATELY BEHIND THE CENTER TURRET.

THE ARMORED CRUISER "RURIK."

RUSSIA'S NEW ADDITION TO HER NAVY.

BY PERCIVAL A. HISLAM.

THE armored cruiser "Rurik," which has recently left the works of Messrs. Vickers, Sons & Maxim on acceptance by the Russian naval commission, is the first large vessel to be completed for the Russian navy since the close of the war with Japan. The designs were originally completed before the close of that conflict, but as a result of the lessons of the war they were considerably modified, the principal alterations taking the direction of greater structural strength and protection against underwater attack.

The "Rurik" is 490 feet long between perpendiculars, with a beam of 75 feet and a normal draft of 26 feet, giving a displacement of 15,200 tons. She has a very powerful armament, consisting of four 10-inch guns, 50 calibers long, twin-mounted in barbettes fore and aft on the center line. Each of these guns can be worked through 35 degrees of elevation and 5 degrees of depression, while the forward guns can be trained 45 degrees abaft the beam, and the after guns 45 degrees before the beam. There are also eight 8-inch 50-caliber guns, twin-mounted in barbettes on the quarters of the ship, having an angle of fire of about 170 deg. For repelling torpedo attack there are twenty 4.7-inch guns of 50 calibers length. Sixteen of these are placed within an armored battery in the center of the ship, separated from each other by specially hardened armor. This battery, being on the upper deck, enables the secondary armament to be placed higher above the waterline than usual. There are four 4.7-inch guns aft, also behind armor, and to counteract the effect of raking fire, three armored bulkheads have been fitted. There are also twelve 47-millimeter, quick-firing guns, and two 18-inch submerged torpedo tubes, one on each bow.

The armament of the ship was subjected to very severe tests, at the instance of the Russian officers who superintended the trials on behalf of the naval commission. For each caliber of gun mounted in the ship a "test" weapon was specially built, and from each of these there were fired 100 rounds with full charges. Following this, 30 rounds were fired from two of the 10-inch guns, and two of the 8-inch guns, and fifteen from all the others, at varying angles of elevation and training. All the guns are operated by electrical mechanism, and the guaranteed rate of fire is two rounds a minute from the 10-inch, three from the 8-inch, and eight from the 4.7-inch guns, representing an aggregate discharge of 16,384 pounds of metal a minute, of which the 10-inch and 8-inch guns account for 9,184 pounds.

The "Rurik" is, for her size, very efficiently protected. She has a main belt 12 feet deep extending for 270 feet of her length, and this belt is 6 inches thick, the material being Krupp steel. At the bows the thickness is reduced to 4 inches, and at the stern to 3. The central battery of 4.7-inch guns is protected by 3 inches of armor, the strake extending for a length of 200 feet and including all the heavy-gun barbettes. These barbettes are constructed of 7¼-inch Krupp steel plates, while the walls of the conning towers, of which there are two, are 8 inches thick. There are two protective decks having a total thickness of 4 inches, and the bases of the funnels are protected by armor casings. The whole of the machinery and magazines below the waterline are surrounded by armored walls extending from the main deck, through the protective decks right to the bottom of the ship, and since this is in addition to the usual double skin, the ship is practically armored from the keel to the upper deck.

The machinery of the "Rurik" consists of two sets of four-cylinder quadruple-expansion engines, steam being supplied by twenty-eight Belleville boilers. The latter work at a pressure of 285 pounds to the square inch, which is reduced to 250 pounds at the engines. There was no full-speed stipulation in the contract, the conditions being that the ship should be able to steam an easy 21 knots with only 75 per cent of her boiler power. This was done for three hours, and then a ten-hour run at full power was made. The results of these and of the other steam trials are shown in the following table:

	Mean of 30 Hours at 12 Knots.	Mean of 30 Hours at 19 Knots.	Mean of 10 Hours at 21 Knots.	Mean of 3 Hours at 21 Knots, with 75% Boiler Power.	Mean of 10 Hours at Full Power.
Steam pressure, pounds per square inch.	196	261	269	273	280
Vacuum, inches	27.12	27	26	25.8	26.2
Revolutions per minute	75.6	123.85	138.48	13[illegible].3	141.6
Indicated horse-power	3,089	13,350	19,355	18,953	20,6[illegible]
Number of boilers in use	8	21	28	21	28
Air pressure in stokeholds, inches	0.13	0.3	0.31	0.58	0.[illegible]

It will be noticed from the accompanying photographs that the "Rurik" differs considerably in appearance from the British cruisers of the "Indomitable" type. The huge tripod masts are missing, the Russian vessel having only a light signaling mast with a searchlight platform low down. The fire-control stations, which are high up on the masts of the British ships, are comparatively low in the "Rurik." They are constructed of 5-inch armor, and are situated a little fore and aft of the masts. The ship came through all her trials with uniform success, and will be a formidable addition to the Czar's navy. It is probable that she will be the last Russian warship to be built abroad, as the naval commission decided last year that all new ships were to be laid down in home yards.

ELECTROLYSIS AND CORROSION.*

HOW RUSTING IS PRODUCED.

BY ALLERTON S. CUSHMAN.

IT is assumed for the purpose of this paper that by corrosion we mean the effects produced on the metals by the combined action of water and oxygen, with or without the stimulus provided by various impurities in the water or in the atmosphere. Few authorities now deny that in this sense of the word corrosion of all metals is simply a matter of electrolysis. It is necessary, however, before proceeding with the discussion to be quite sure that we are all accepting the same definition of electrolysis. The word was first used by Faraday to express the decomposition of compounds by the electric current, but to-day it is used in a wider sense, and electrolytic phenomena are recognized whenever a strip of any ordinary metal is immersed in water. There has unfortunately been a widespread impression that electrolysis, as it applies to the corrosion of metals, can take place only if the electricity, or electrical circuit involved, can be traced to some definite extraneous source. Thus it has come about that engineers, metallurgists and others to whom the causes of deep corrosion and pitting of metals is a matter of anxious inquiry, have wasted much valuable time feeling about with voltmeters and galvanometers in vain efforts to locate and insulate the dangerous intruder. While it is not my present intention to combat the idea that stray, escaped currents play a contributory part in some cases of corrosion, I wish to point out emphatically that corrosion is eternally going on where no extraneous currents can be held responsible for the damage.

In order to understand exactly what is meant it will be necessary to consider briefly the modern physicochemical explanation of electrolytic solution-tension. It is well known that when a liquid or a solid is heated, some of the molecules pass into the form of vapor or gas, and in any closed space equilibrium is established for a given temperature when the vapor exerts a certain definite pressure. As Nernst, who first gave expression to this phase of the modern theory of solution, puts it: "If, in accordance with Van't Hoff's theory, we assume that the molecules of a substance in solution exist under a definite pressure, we must ascribe to a dissolving substance in contact with a solvent, similarly a power of expansion, for here also the molecules are driven into a space in which they exist under a certain pressure. It is evident that every substance will pass into solution until the osmotic partial pressure of the molecules in the solution is equal to the solution-tension of the substance."

To use a rough analogy, this is no more complicated than saying that a company of people pressing from one room into another will find themselves in comfortable equilibrium just as soon as the expansive power of the company in the newly occupied space is about equal to that left in the originally overcrowded one. It should be understood, however, that individuals may be passing continually backward and forward between the rooms without essentially disturbing the equilibrium, but if we further assume that some barrier or force prevents a person having once passed into the new room from exerting back-pressure, the stream of new arrivals will continue, to the depletion of the company in the original room. Also precisely the same result would accrue if the individuals pressing into the second room were slowly but constantly being removed by passing down a narrow stairway and thus being removed from the scene of action. Leaving now this rough analogy, whose application, however, will soon be apparent, we may return to Nernst's conception of solution-tension. The metals, probably without a single exception, have the possibility of passing into solution as positive ions, that is to say, as atoms carrying relatively to their mass enormous static charges of positive electricity. Every metal in water has a solution-tension peculiar to itself, provided it is pure, but, as we shall see, this property is enormously modified under most circumstances by a most remarkably small presence of certain impurities. To quote from a well-known text-book, Jones's "Elements of Physical Chemistry":

"If we dip a metal into pure water, let us see what will take place. In consequence of the solution-tension of the metal, some ions will pass into solution. When metallic atoms pass over into ions they must secure positive electricity from some thing. They take it from the metal itself, which thus becomes negative. The solution becomes positive, because of the positive ions that it has received. At the plane of contact of the metal and solution there is formed the so-called electrical double layer, whose existence was much earlier recognized by Helmholtz. The positively charged ions in the solution and the negatively charged metal attract one another and a difference of potential arises. The solution-tension of the metal tends to force more ions into solution, while the electrostatic attraction of the double layer is in opposition to this. Equilibrium is established when the two forces are equal. Since the ions carry such enormous charges, the number that will pass into solution before equilibrium is established is so small that they cannot be detected by any ordinary method."

It is apparent from this, that since under the ordinary conditions of service metals suffer corrosion only by first passing into solution, the corrosion can only be prevented or inhibited either by aiding the resistance to the entrance of more ions into solution or by covering the surface of the metal with a waterproof coating, or by doing both these things at the same time, on the principle that a double barrier is more impregnable than a single one. If we had to deal always with chemically pure 100 per cent metals which were also perfectly physically constant as to surface conditions, and if natural waters were absolutely pure, the electrical double layer would be sufficient to protect all metals from continuous corrosion. Needless to state, this is not the case. Let us then examine the forces which are operating in the direction of continued corrosion, as an understanding of these may point the way to various methods of throwing against them opposing forces. It is well known that even the purest water that it is possible to pre-

* A paper read before the American Society for Testing Materials.

pure is to some extent dissociated; that is to say, it contains free positively charged hydrogen ions, while ordinary natural water contains very many more free ions than pure water, as the measurement of its electric conductivity serves to show.

When this is the case the entering metallic ions do not have to take their positive charges with them, leaving the metal surface negative, but they now assume the positive charges carried by the hydrogen ions, which immediately pass into the atomic condition and make their exit from the system, as effectually as the individuals in our analogy did by proceeding down the staircase. Relieved of the pressure of the hydrogen ions further dissociation of the water takes place and the action may thus go on continuously, although in the case of most metals it is so exceedingly slow that it is not visible to the eye. The direct result of this action is that the electrical double layer is continually being broken down and if it breaks down at weak spots, which for any reason whatsoever exist on the surface of contact, we shall have corrosion taking place more rapidly at some points than at others and the results will be a pitting effect.

Leaving this phase of the subject for the present, if we inquire which among the common metals have high and which low solution-tensions, we shall find that magnesium, zinc, aluminium, iron, and the like are always negative when in solutions of their own salts. This means that the solution-tension of the metal is always greater than the osmotic pressure of the metal ion in any solution that can be prepared. On the other hand, with such metals as gold, silver, mercury, and copper the metal is usually positive when immersed in a fairly strong solution of its salt, although in very diluted solutions even these metals may appear negative.

Among the metals iron is unique in the fact that its physical characteristics are tremendously modified and changed by the presence of extremely minute quantities of other elements; thus, to mention one well-known instance, the electrical resistance of iron rises rapidly with an extremely small increase in the manganese content. That the surfaces of specimens of iron, when wetted, throw themselves into positive and negative nodes, corrosion taking place more rapidly at the positive poles, has been shown by means of the ferroxyl indicator, which was described in a previous paper (Bulletin 30, Office of Public Roads, U. S. Department of Agriculture). It will be interesting now to consider and, if possible, to interpret the facts disclosed by this test, as well as the general subject of rusting of iron, in the light of the modern theories of physical chemistry.

When a strip of ordinary steel is wetted with pure water, iron ions under the pressure of solution-tension pass into solution, but, owing to the uneven electrical condition of the surface, local couples are formed, and the solution is stimulated at the positive poles while it is resisted at the negatives. If no oxygen is present, however, equilibrium is established by the formation of an electrical double layer before any visible damage is done. In other words, the positive iron ions tend to cluster or crowd about the point of their formation where they have inevitably left the metal slightly negative and the continued entrance of more iron into solution is thus resisted. Once admit molecular oxygen to the system, however, and the condition of affairs changes. As is well known, molecular or atmospheric oxygen has the power of oxidizing ferrous ions to the ferric condition, which results in the precipitation by hydrolysis of the insoluble hydrated ferric oxide which is called rust, and its consequent removal from the solution system. As ferric hydroxide tends to migrate to the negative pole the inevitable result is that the clustering ferrous ions are removed, one is tempted to say dragged, away from the entrance, the electrical double layer is destroyed and more and more iron ions stream in as time goes on, only to be in turn removed by oxygen. Thus the damage from pitting slowly but surely proceeds. The conclusion to jump at is that if we must admit water to the surface of iron or steel, it is dangerous to admit oxygen, too. And at this point we find an explanation of some interesting facts that Prof. W. H. Walker is at present studying, and to which he first called my attention; namely, that tannic acid and pyrogallic acid when introduced into boiler water prevent pitting. Since these organic compounds take the dissolved oxygen in the water, there is but little left over to attack the ferrous ions.

Since oxygen undoubtedly plays such an important part in the corrosion of iron, how, it may be asked, are we to find an explanation of the now widely known fact that such strong oxidizing agents as chromic acid and its salts prevent the corrosion of iron. The paradox seems the greater when we proceed to the consideration of this phase of the subject directly after having pointed out that a strong reducing agent like pyrogallic acid produces the same result. In order to understand the subject better, we must review what is known about the so-called passive state into which certain metals may be put, and here again I shall quote from Jones's "Physical Chemistry":

"It has long been known that when certain of the metals are subjected to special kinds of treatment they no longer have the properties that they usually possess. As early as 1790 Kier observed that when iron is dipped in nitric acid having a specific gravity of 1.45 it becomes passive, i. e., it is no longer attacked by dilute nitric acid. Further, it no longer has the power to precipitate metallic copper from a solution of a copper salt.

"Other strong oxidizing agents, such as chromic acid, also render the iron passive. The same result is frequently obtained when iron is made the anode in electrolysis.

"A number of metals other than iron can be rendered passive. We should mention especially chromium, copper, cobalt, and nickel.

"A number of attempts have been made to explain the passivity of the metals. Faraday and Schönbein explained the passivity in the case of iron, as due to the formation of a layer of oxide on the surface of the metal. This was natural when we consider that iron is rendered passive by strong oxidizing agents and loses its passivity when heated in a reducing gas.

"The oxide layer theory of passivity is now regarded as untenable, since the passive state has been brought about under conditions where oxidation is impossible; and, further, has been destroyed under conditions where any layer of oxide would not be disturbed.

"The same fate has befallen the theory that passivity is due to the formation of a protective layer of gas over the surface of the metal. The two views of passivity that have acquired the greatest prominence are those of Finkelstein and Hittorf. According to the former, active iron is bivalent and passive iron trivalent. This conclusion was based upon the difference in potential between iron electrodes and the iron salt in which they were immersed. The potential difference depends upon whether the iron salt is in the ferrous or in the ferric condition.

"Hittorf also points out that in the case of chromium the passive condition corresponds to the highest valence, and the active to the lower valence. He thinks that we have to do with two allotropic modifications of the elements, one of which is active and the other not."

If Finkelstein and Hittorf are correct, and the experimental work appears to justify their conclusions, the action of chromic acid and its salts in preventing the corrosion when present in sufficient concentration is very simply explained. Passive trivalent iron does not pass into solution and ionize and the reaction which produces oxidation cannot proceed. The second theory, however, which holds that the protection afforded by chromic acid is due to a polarization effect, and that the metallic surface is actually plated with ionic oxygen, is still very widely held in spite of the opinion advanced in the above quotation. Moreover, the polarization theory explains other effects which have been observed in the course of recent investigation along these lines, carried on independently by W. H. Walker and by myself. In my own laboratory it was observed that in making ferroxyl mounts an identation, scratch, or wound of any kind on the surface of the steel invariably became positive to its surrounding area, and thus formed a center of corrosion. If this had occurred only upon mill specimens, which carried a coat of scale or blue oxide, the explanation would be simple, but the fact is, if a freshly polished steel mirror receives a cut or wound before immersion, the marked place comes out in blue and corrosion naturally takes place more rapidly at the positive spots.

The fact thus brought out by experimental investigation has a direct bearing upon the results of observation in practice. I am informed by Commander Parks of the U. S. Navy Department that it has been known for a long time that indentations or injuries on the water surfaces of boilers always become centers of corrosion and pitting. It is certain that inspection should be very thorough in regard to this point, where resistance to corrosion is a matter of prime importance. It is a question whether the smoothing up and actual polishing of surfaces would not in the long run repay the trouble and expense. There are times when a sound boiler tube is of vastly more importance than a polished gun barrel.

It would seem from the facts brought out by the ferroxyl test that the polarization effects which take place on the surfaces of iron or steel are determined by a number of widely different causes which may be classified as electrical, chemical, and mechanical. It seems probable that the surfaces of steel which are subject to the condensation moisture of the atmosphere are always in a certain state of electrical strain and polarity. Any change produced on the surface by cutting, stressing, or straining upsets the equilibrium, with the result that certain surface points are depolarized. The ferroxyl tests show that in the very large majority of cases the positive spots once formed remain positive and so corrosion proceeds steadily to the formation of destructive pit holes.

As has been pointed out in previous papers, the purer and more homogeneous, chemically speaking, the iron or steel, the less liable is the metal to suffer from localized rusting leading to pitting; but besides the important bearing which this chemical homogeneity has upon the problem, we now see that the physical and mechanical condition of the surface is of the greatest importance. It is undoubtedly true, as Burgess and Walker have shown, that the rapidity of corrosion is modified by the condition of strain that the metal may be under, and this, as has been pointed out, is undoubtedly due to the changes set up in the electrical state or condition of polarity on the surface of the metal. Again, the presence and distribution of mill scale on the surface is a modifying factor, as has been shown by Walker in an exceedingly interesting experiment.

All these factors must be taken into consideration when attacking this interesting and intricate subject, but I should wish to urge upon metallurgists the prime importance of studying the effects of the usual metallic impurities which accompany nearly all forms of merchantable iron and steel. Already many metallurgists are agreeing that the use of manganese in steel making has been overdone, and they are seeking to reduce the manganese content to the lowest practicable quantity. It was new to me until a few months ago, and I think must have been overlooked by many other workers along these lines, that impure metallic manganese, when in a fairly finely divided condition, is soluble in water, decomposing it with a rapid evolution of hydrogen. Since this is the case it is not surprising, if even slight segregation has taken place in manganiferous steel, that the polarization effects would be modified and increased.

Another interesting experiment shows that certain metals can be so mixed as to give off a very rapid evolution of hydrogen when brought in contact with cold water. I have studied the action of water on a number of combinations of metals by mixing them together in the form of powders and then compressing the mixtures in a die into tablets under a pressure of 50,000 pounds to the square inch. The amount of hydrogen given off and collected in a given time by equal weights of these compressed tablets when acted on by cold water is distinctly modified and determined by the electrolytic effects which are produced. Metallic magnesium is stated in the text-books on the authority of Liebig, Bunsen, and others, not to decompose cold water, but we have not as yet encountered a sample of magnesium that did not vigorously give off bubbles of hydrogen in cold water. An interesting experiment can be shown in which tablets made from pure aluminium and pure zinc are placed in cold water side by side with a compressed alloy of the two. The first two tablets are not visibly attacked by the water, while the hydrogen comes from the alloy with all the vigor exhibited by an effervescent salt.

It is safe to state that the tendency of metallic impurities to produce electrolytic effects on the active surfaces of the various industrial metals, has not received the attention that the problem demands.

As I stated last year, there are two distinct lines along which progress may be made in combating the damage done by corrosion. One is a metallurgical and the other a paint problem. It is sufficient to state here that the evident palliative measure of applying a first or prime coat containing a substance which prevents corrosion by inhibiting electrolysis gives great promise for future experimental work.

It has been frequently shown that alkalies inhibit corrosion while acids stimulate it, for reasons which have been discussed in recent publications. It would be well worth trying whether trenching with lime would not furnish protection to steel pipe lines that have been reported as giving trouble. Although the electrolytic theory of the corrosion of the metals may not have met with universal acceptance, it is difficult to see how it can be rejected in view of the evidence that has been brought forward by recent workers in this field. But whether it survives or not, like other good theories, it will serve a purpose in suggesting methods of overcoming existing difficulties.

A new form of portable telephone apparatus has been lately devised by a German company. It is intended to be used specially for connecting with the telephone wires which are mounted upon the same poles as the wires of power lines from electric stations, and in order to avoid accidents which might be occasioned by the high-tension current of the power lines, the new telephone apparatus is insulated so that it can be used with great security in the presence of 10,000-volt wires which run on the same poles. At the same time the conversation is very clear even at great distances. The apparatus, which is compact and easily handled, consists of a telephone mounted in a rain-proof casing and adapted to be set up on a special tripod which gives a ground connection and is made of light steel tubes. For making the connection from the telephone to the overhead wire there is mounted a long pole which is made in six sections of ash wood. In this way the telephone can be connected at any point along the line and without any risk.

LONGITUDINAL STABILITY OF AEROPLANES.

A METHOD OF KEEPING THE LINE OF THRUST OF PROPELLERS ALWAYS HORIZONTAL.

BY HENRY T. STRONG.

DESPITE the efforts of inventors the world over, a satisfactory system of longitudinal stability has not up to the present been evolved, and the development of the automatically stable flying machine has accordingly been extremely slow.

A satisfactory solution along non-automatic lines would seem improbable owing to the large part which must always be played by the personal skill of the aviator. The future development of the art of aviation will undoubtedly depend upon the discovery of a satisfactory system of automatic stability.

In the quest for such a system the importance of maintaining the thrust of the propelling force constant in direction, that is to say, independent of the longitudinal oscillations of the machine itself, would seem to have been overlooked by the majority of inventors.

In the present article a method of securing the above result which is applicable to all machines of the aeroplane type will be described and the important results which would follow pointed out. Fig. 1 represents its application to a machine of the Langley type.

The novel feature consists in mounting the propellers in a frame, *R* (which will be referred to hereafter as the "rocking frame") carried in bearings at *c*, *d*, and *e*, and free to rock about its longitudinal axis, *C D* (which axis will be referred to hereafter as the "rocking axis of the frame"), the said axis lying across the machine in the horizontal plane at right angles to the direction of flight.

The plane of rotation of the propellers is maintained vertical by means of a balance weight *W* secured to the rocking frame by the forked rod *e* and shielded from the wind by a "wind case," *h*. The power is transmitted to the propellers by the flexible shafts *f f*.

The conditions to be fulfilled with regard to the rocking frame are as follows:

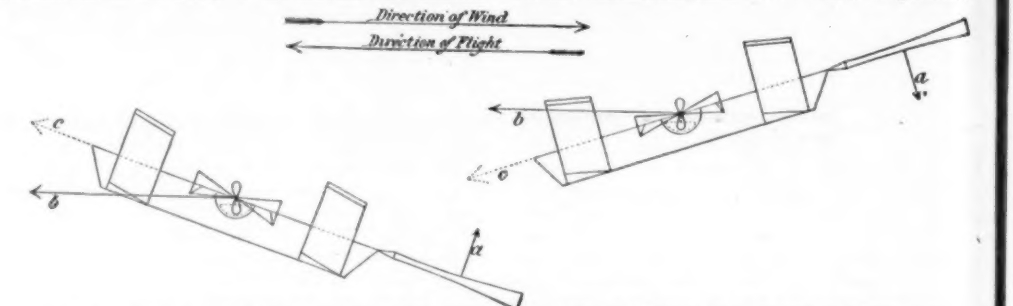
1. Any number of rocking frames may be carried by a machine.
2. The line of thrust of each propeller or the combined line of thrust of the propellers in any one rocking frame must intersect its rocking axis.
3. The gyrostatical properties of all the propellers in a rocking frame must be the same.
4. The number of propellers in any one rocking frame must always be an even number, or if not, means must be adopted to neutralize the gyrostatical torque of the odd propeller, in so far as it would tend to produce rotation of the frame about its rocking axis.
5. Half the number of propellers in a rocking frame must rotate in the opposite direction to the other half, at the same speed and in symmetrical phase, in order that their gyrostatical properties may neutralize for turning movements of the machine in the horizontal plane.
6. The center of gravity of each propeller must lie in its axis of rotation.
7. The center of action of all gravitational forces acting on the rocking frame must lie below its rocking axis in the plane, at right angles to the line of thrust, which contains that axis.
8. The moment of inertia of the rocking frame about its rocking axis should be as small as possible.
9. All power required on the rocking frame must be transmitted thereto by flexible shafting or other suitable means which will not interfere with the free motion of the frame about its rocking axis.

It will be seen that if the above conditions are fulfilled, there will be no unbalanced forces acting on the rocking frame tending to rotate it about its rocking axis, and the propellers will continue to rotate in the vertical plane independent of the longitudinal oscillations of the machine itself. Owing, however, to fluctuations in the speed of the machine the balance weight will tend to oscillate and thus deflect the propellers from the vertical. In order to check this tendency, as far as possible, the propellers should be mounted in the rocking frame in such a manner that their gyrostatical properties are available to resist rotative movements of the frame about its rocking axis. In the figure, the rear bearing of each propeller is shown pivoted vertically at *p*, while the front bearing can slide on the frame in a path which is circular about the pivot *p* of the former. The "precessional" movements of the axis of rotation being thus permitted, the gyrostatical properties of the propellers become available to resist rotative movements of the frame about its rocking axis, and thus exert a damping action on the movements of the balance weight. In addition to this the inertia of the air in which the propellers may be rotating at any instant will also produce a similar effect. But the weight and leverage of the balance weight must be so proportioned to the total damping forces opposing its motion, that it can restore the plane of rotation of the propellers to the vertical, should they be displaced therefrom, with sufficient rapidity, this condition to be determined by experiment.

Now it will be seen that when the propeller thrust is maintained constant in direction, and acts close to the center of pressure of the sustaining surfaces, the longitudinal oscillations of the machine will take place, principally, about an axis passing horizontally through the center of thrust of the propelling force, at right angles to the direction of flight. It will be convenient to refer to this axis as the "principal rocking axis" of the machine.*

In the design of the aeroplane the following conditions should be observed:

1. The center of gravity of the machine, the center of pressure of the sustaining surfaces, and the center of thrust of the propelling force should coincide as far as possible; but since the center of pressure advances somewhat with increase of speed, it may be found advantageous to have the center of thrust slightly in advance of the mean position of the center of pressure.
2. The center of pressure of the whole machine in the direction of flight must always lie to the rear of the center of thrust of the propelling force.
3. The moment of inertia of the whole machine about its principal rocking axis should be as small as practicable, in order that the duration of the longitudinal oscillations shall be as short as possible.



FIGS. 2 AND 3.—AEROPLANE TILTED UPWARD AND DOWNWARD, WHILE LINE OF THRUST OF PROPELLERS REMAINS HORIZONTAL.

If the center of gravity of the machine and the center of thrust of the propelling force do not coincide with the center of pressure of the sustaining surfaces, or at all events lie in the same horizontal plane, fluctuations in speed will tend to make the machine oscillate about its center of gravity.

The advantages of maintaining the propeller thrust constantly horizontal will be obvious on reference to Figs. 2 and 3. Fig. 2 illustrates the case in which the machine has been tilted upward by a sudden increase in the velocity of the wind, while Fig. 3 represents the analogous condition in which the front of the machine has become depressed by a sudden decrease in the wind velocity.

As the propeller thrust *b* remains horizontal, and therefore urges the machine constantly in that direction, it will be seen that in both cases the pressure of the wind *a* on the tail piece tends to swing the machine back to the horizontal position and thus maintain the equilibrium, whereas, were the propellers mounted in the usual manner, the line of thrust would be deflected along with the machine and simply urge it in the new direction as indicated by the dotted arrow *c*. The propellers could therefore not assist in maintaining the equilibrium; and as the machine's momentum in the direction of flight would be rapidly destroyed, a capsize would probably result, the action of gravity alone having been found insufficient in practice to maintain the equilibrium.

A further advantage which might accrue from the use of a constantly horizontal line of thrust is increased sustaining power. For it has been shown by the late Prof. Langley that the wind is not a steady current of air but, ordinarily, consists of a series of gusts of varying velocity separated by intervals of comparative calm. Langley sought to explain the soaring flight of birds by assuming that the bird during the intervals between the gusts glided downward to some extent, thereby gaining momentum which enabled it to rise to its former elevation, or even higher, on the next succeeding gust. If this theory be correct, an aeroplane with a constantly horizontal propeller thrust might be found to possess superior sustaining power, for a constantly horizontal line of thrust would maintain a greater average momentum in the direction of flight than would be accomplished by a thrust which varied its inclination to the horizontal.

Moreover, the above method of maintaining the equilibrium besides being automatic is free from defects inherent in the use of a horizontal rudder, placed in front of the machine, the action of which is such as to resist the onward progress of the machine and has a tendency to resist soaring. A horizontal rudder would have to be carried, however, as the stability would be only good while the propellers were running.

Although with the propellers mounted in the manner described above the line of thrust might be found to undergo some deviations from the horizontal in practice, still, provided such deviations were small compared with those undergone by the machine itself, the stability would be good. When applied to the tailless machine of the Wright type, the propellers must be placed in front of the sustaining surfaces.

Their action in this case would be somewhat different, being equivalent to that of the horizontal rudder, and the principal rocking axis would then probably pass through the center of gravity of the main portion of the machine and not through the center of thrust as in the former case.

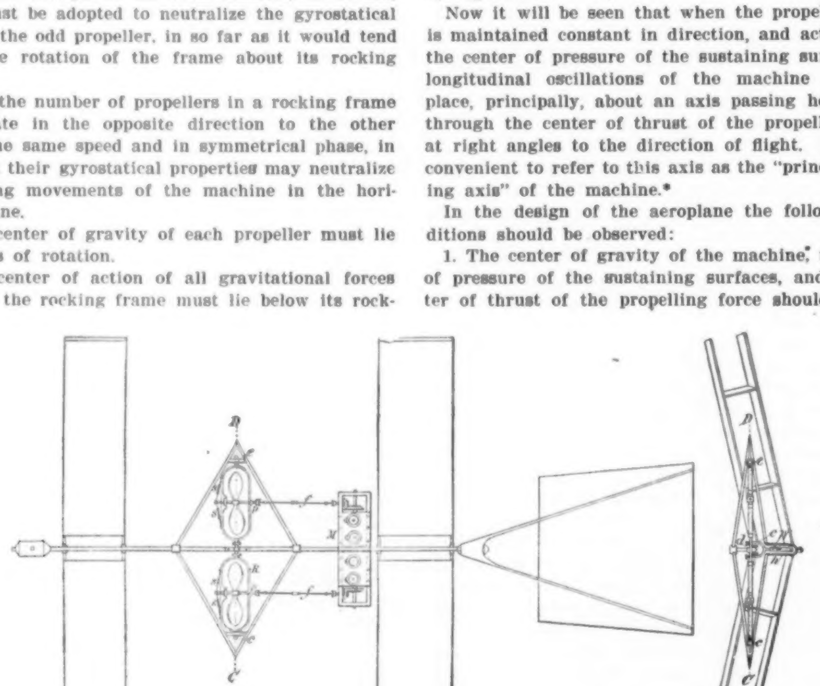


FIG. 1.—PLAN VIEW OF AEROPLANE AND CROSS SECTION THROUGH *C D*.

* If only one rocking frame is carried by a machine, the rocking axis of the frame will, under these circumstances, be also the principal rocking axis of the machine.

FOREIGN TRADE IN AUTOMOBILES.*

THE REMARKABLE DEVELOPMENT OF AN INFANT INDUSTRY.

BY JOHN J. MACFARLANE.

TEN years ago the foreign trade in automobiles was not of sufficient importance to be given a place by any country in the list of its imports and exports. In 1906 the exports alone of automobiles from the seven leading automobile manufacturing countries amounted to 42 million dollars. The entire foreign trade, if both exports and imports were counted, would amount to nearly 100 million dollars.

The following table of imports and exports of automobiles includes all available statistics of the leading countries. It will be seen from it that France first mentions automobiles as a separate item in its statistics in 1898; the United States and Italy in 1900; Germany and Belgium in 1901, and Great Britain in 1902.

UNITED STATES IMPORT OF AUTOMOBILES.

Fiscal year ending June 30, 1907. Total value, $4,041,025. Values in thousands of dollars, 000's being omitted.

AUTOMOBILES—IMPORTS AND EXPORTS.

[Values given in thousands of dollars.

Years.	France.		Italy.		United States.*		Germany.		Belgium.		Great Britain.	
	Imports.	Exports.	Imports.	Exports.	Imports.	Exports.†	Imports.	Exports.	Imports.	Exports.	Imports.	Exports.
1898	77	337	....	....	....	....	....	....	....	....	....	....
1899	91	821	....	....	....	....	....	....	....	....	....	....
1900	100	1,817	232	7	43	....	....	....	....	....	....	....
1901	130	3,046	451	20	530	948	340	554	77	165	....	....
1902	208	5,835	415	33	963	1,207	846	1,129	109	231	4,827	754
1903	244	9,811	541	112	1,294	1,885	1,197	1,250	101	254	8,340	1,387
1904	740	13,710	790	214	2,297	2,481	1,649	2,491	166	328	10,122	1,167
1905	835	19,351	1,261	510	3,844	3,497	3,132	3,397	201	756	11,874	1,830
1906	1,531	26,606	1,910	2,286	4,041	5,502	3,979	4,200	240	1,097	12,100	2,408

* United States statistics are for fiscal years ending June 30 of following years. † United States exports include automobiles and parts.

The chart shows the relative value of the exports of automobiles from the leading countries in 1906. In the case of Belgium the value is for 1905, and of the United States the value is for the fiscal year ending June 30, 1907, as that is the first year in which the value of the automobiles is given separately from that of the parts.

From this chart it will be seen that the value of the exports of automobiles from France is greater than that from all other countries combined. The United States ranks second, followed in order by Germany, Great Britain, and Italy. From the table it will be seen that these countries are also the largest importers of automobiles, about 57 per cent of the exports being sold to these countries. Great Britain leads as an importer of automobiles, followed in order of value by the United States, Germany, Italy, France, Australia, Switzerland, Canada, and Argentina.

EXPORT OF AUTOMOBILES BY COUNTRIES.

Total value, 1906, $42,000,000. Values in thousands of dollars, 000's being omitted.

Taking up the several countries mentioned in the table, it will be possible to obtain a fair idea of the course of the foreign trade in automobiles. France, which is the largest exporter, has steadily increased its exports from 337 thousand dollars in 1898 to 26 million in 1906, and during the nine months of 1907 ending September 30, exported 21 million dollars' worth, or over a million dollars more than in the same period of 1906. While France is still increasing its exports it has already felt the effect of the competition of other nations, the increase in the value of the exports being less than in former years.

The countries to which France exported over a million dollars' worth in 1905 were as follows:

Great Britain	$9,600,000
Germany	2,200,000
Belgium	1,900,000
United States	1,300,000

Among countries less than a million were Italy, Argentina, Algeria, Russia, Spain, and Austria.

France imported last year more than in any two preceding years. More than one-half of these imports are from Germany. The valuation of automobiles in the French statistics is 10 francs per kilogramme, and not at invoiced value as in the United States.

In Great Britain the demand for automobiles is so great that the factories have been unable to keep up the supply. The following table will give an idea of the increase in imports since 1902:

		Automobiles. Number.	Value.	Parts. Value.
Imports	1902	3,747	$5,376,000	$540,000
	1906	5,776	12,098,000	9,117,000
Exports	1902	415	754,000	82,000
	1906	1,380	2,413,000	1,576,000

Great Britain is the largest market not only for automobiles, but also for automobile parts. The value of the parts imported in 1906 was double that of 1905. During the ten months ending October 31, 1907, two million dollars worth less of automobiles were imported and one and a half million dollars worth more exported than in the same ten months of 1906. There were also 2.5 million dollars worth more of parts imported during these ten months than in the same period in 1906. Of the automobiles and parts imported two-thirds came from France. Of the exports two-thirds were sold to British possessions—India, Australia, New Zealand, and South Africa taking large quantities. Among foreign countries the United States, Argentina, Italy, and France were the largest buyers.

In Germany the value of the imports of automobiles steadily gained upon that of exports until 1906 when they were almost the same. In the first nine months of 1907, however, the imports increased and the exports fell back, so that Germany will import more this year than it will export. The valuation of automobiles, according to the German tariff, is 10 marks per kilogramme for motor carriages and 4 marks per kilogramme for commercial wagons. This is the only nation which makes the distinction between these two classes of vehicles.

Of the imports into Germany three-fourths were from France. Of the exports one-fourth was sent to France. Great Britain ranks first in the exports from Germany. Nearly one-half of those going to Great Britain was made up of commercial wagons. The other nations in the order of values, to which Germany exported are Austria, Belgium, United States, Italy, and Switzerland.

In the nine months of 1907 Germany imported 1,559 automobiles, valued at $3,500,000, of which 31 were commercial wagons. During the same period it exported 995 automobiles, valued at $2,793,000, of which 221 were commercial wagons. There has been a falling off of $400,000 in the value of exports and an increase of $320,000 in the value of imports over the same period in 1906.

In Italy there has been a wonderful development in the automobile industry, more especially around Turin, which city is claimed by the Italians to be the largest automobile manufacturing city in the world, but it is hardly probable that it exceeds Detroit in the annual value of its output.

UNITED STATES EXPORT OF AUTOMOBILES AND PARTS.

Fiscal year ending June 30, 1907. Total value, $5,502,241. Values in thousands of dollars, 000's being omitted.

The exports of automobiles from Italy have increased from 6 in 1900, valued at $7,000, to 829 in 1906, valued at $2,286,000, this latter being four times as much as in the year 1905, and this ratio of increase has continued during the six months of 1907, in which the value of automobiles exported was almost as great as during the whole of 1906. At the same time there was a decrease in the imports of automobiles.

Belgium is also beginning to take an active place in the export market of automobiles, and while because of its small population it does not import many automobiles, in 1906 it passed the million-dollar mark in the value of the exports of this class of goods.

Before taking up the foreign trade of the United States, it might be well to consider first its production. This is the only country in which we have official statistics giving the value of the production of automobiles.

According to the census of 1900 the value of the products of the automobile industry in the United States was $4,748,000 during the census year (1899), while in the census of 1905 the value is given as $26,645,000 for the census year (1904), an increase of 461 per cent, and according to sworn testimony given in court in a patent case, the value of the production in 1905 was $31,814,000.

There were 21,692 automobiles manufactured in the census year 1904, 18,699 of which were gasoline cars. Out of the total number 12,131 were runabouts, valued at $8,800,000, and 7,220 touring cars, valued at $11,781,000. It is estimated that in 1907 40,000 cars were manufactured, valued at about 80 million dollars, and that in 1908 there will be 50,000 cars manufactured representing over 100 million dollars in selling value. This is wonderful for an industry not much more than ten years old.

In 1900 the leading automobile manufacturing States were Illinois, Massachusetts, New Jersey, New York, Ohio, and Pennsylvania. In 1905 both Ohio and Michigan made more than the whole country in 1900.

UNITED STATES PRODUCTION OF AUTOMOBILES BY STATES.

Total value, 1905, $26,645,064. Values in thousands of dollars, 000's being omitted.

The chart gives the States in the order of value of production. None of the States manufactured a million dollars worth in 1900, while eight manufactured more than a million in 1905.

Eighty per cent of the value of the products in

* Abstracted from Commercial America.

this industry is credited to cities of over 20,000 population, 86 establishments out of 121 being in these cities. The leading cities with the value of their output as given by the census are as follows:

Detroit	$5,382,000
Cleveland	4,256,000
Buffalo	1,385,000
New York	1,186,000
Indianapolis	797,000

Detroit and Cleveland are credited with more than one-third of the total production in 1905, and the five cities given produce almost one-half.

A curious fact in connection with this trade is that the manufacture of automobiles has largely taken the place of that of bicycles. The value of the output of the former industry increased in the five years from 1900 to 1905 from almost 5 million dollars to over 26 million, while the value of the products of the bicycle industry decreased from 32 million dollars in 1900 to 5 million in 1906.

The imports of automobiles into the United States has increased from 26 in 1901, valued at $43,129, to 1,176 in 1907, valued at $4,041,000. In 1907, 841 automobiles, valued at $2,940,000, came from France; 144 from Italy; 104 from Great Britain; 61 from Germany, and 27 from other countries. It will thus be seen that two-thirds come from France. In addition there were also $801,000 worth of automobile parts imported in the year ending June 30, 1907.

It took some years for the United States to attain a prominent position as an exporter of automobiles, but it now ranks second only to France, exporting in 1907, 2,862 automobiles, valued at $4,890,000.

In the chart of the exports of automobiles from the United States by countries the value of the parts is also included. This amounts to $611,000 for all countries. From this chart it can be seen that Great Britain is the largest purchaser, followed by the British colony of Canada, these two alone taking nearly one-half of all the exports from the United States.

The high character of American automobiles is evidenced by the fact that European manufacturing nations, which include all the manufacturing centers outside of the United States, purchased one-half of all the exports from the United States. To persons in other countries considering the purchase of automobiles, either for sale or use, this should be a recommendation of the American product.

THE THERMAL VALUE OF FUELS.*

A COMPARATIVE ESTIMATE.

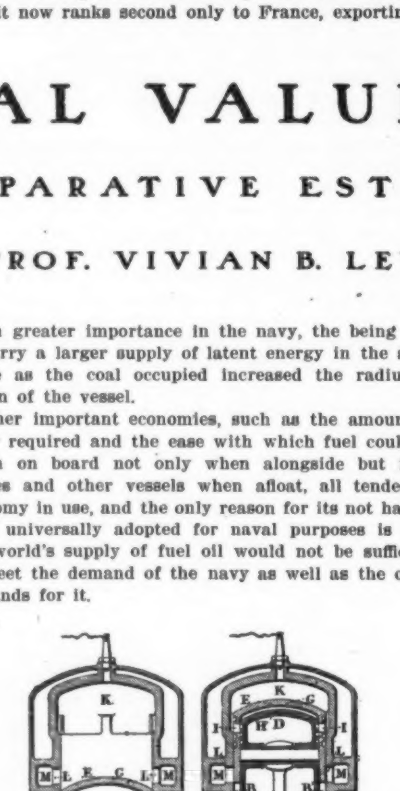
BY PROF. VIVIAN B. LEWES.

THE calorific value of a fuel is chiefly of use in giving a comparison between the fuels themselves, and in its utilization we must take into consideration the work which that fuel has to do and how far it is fitted to that work. If we were restricted to the use of coal and required a high local intensity for the fusion of a metal in a furnace, anthracite, which burns with hardly any flame and gives great local heat during the combustion of the high percentage of carbon it contains, would be manifestly the best fuel to employ, while if one required a considerable volume of flame to generate heat in the combustion chamber and tubes of a marine boiler, we should find that the more bituminous coals, although giving plenty of flame, would at the same time give too much smoke. Natural fitting of the fuel to the work would eventually lead to the adoption of Welsh steam coal, which would give us a maximum of heat and flame in the furnace and tubes with a minimum of smoke from the funnel; that is, we should by a practical process of elimination arrive at the point at which we could get the highest efficiency from the fuel. When, however, we came to make up the balance-sheet of thermal units which we had first of all utilized in the generation of steam and then converted into power by means of the marine engine, we should find that it would be only a small proportion of the energy latent in the coal which had been translated into work, so that the real question for solution would be more dependent upon the suitability of the fuel; that is, the ease with which it could be used and the amount of power that was originally in it.

During the first half of the last century it was solid fuel only that was employed for the generation of heat and power, but the last half of the century has seen the advent of liquid and gaseous fuels, which, under certain conditions, proved themselves of the greatest value. Certain processes are now largely dependent upon their use, this being due to the ease of application, which has meant economy in labor and greater facility for converting the heat into work. As an example of the ease of application making a fuel of poor calorific value more effective in use than coal of high quality, one may instance such manufactures as those of glass, where in the heating by solid fuel the necessary temperature had to be imparted to the mass of raw material through the walls of a thick fire-clay retort, the difficulty of application here being dependent upon the fact that the crucible had to be heated to a very high temperature to get the necessary fusing point of the glass mixture. Maintaining this for a considerable period meant a big expenditure in fuel and great wear and tear to the furnace and containing vessel. It was clear that if the solid fuel could be gasified, and the clean flame made to play directly on to the surface of the mixture to be fused, instead of having to impart the heat through the walls of the containing vessel, an enormous economy would be obtained, and this is now done by the utilization of producer gas and regeneration in the continuous tank processes.

In the same way liquid fuel, as soon as methods could be found for its proper combustion, presented such wonderful economies and advantages for marine work that, in spite of its being dearer than coal, it at once found a place in both the navy and the mercantile marine. The possibility of being able to store it below the level of the boiler in the ballast tanks instead of having, as in coal bunkers, to have the storage above that level, at once gave increased space in the important part of the vessel, and, what was of much greater importance in the navy, the being able to carry a larger supply of latent energy in the same space as the coal occupied increased the radius of action of the vessel.

Other important economies, such as the amount of labor required and the ease with which fuel could be taken on board not only when alongside but from barges and other vessels when afloat, all tended to economy in use, and the only reason for its not having been universally adopted for naval purposes is that the world's supply of fuel oil would not be sufficient to meet the demand of the navy as well as the other demands for it.



THE DA COSTA TWO-CYCLE EXPLOSION MOTOR.

The total oil output of the world may be taken as being about 20 million tons per annum as against 800 million of coal, and of this oil at best only one-third is available for fuel purposes. The crude oil, as it comes from the well, would be absolutely unfitted for use, as in most cases it gives off inflammable vapors at air temperatures, and these mingling with the air form highly explosive mixtures. The temperature at which such inflammable vapor is evolved is called the "flash point" of the oil, and for use in the British navy, no oil with a flash point below 200 deg. F. is allowed on board, although in the German navy and the mercantile marine, the limit is fixed at 150 deg. This necessary limitation means that the crude oil, as it comes from the well, has first to undergo a process of distillation, the more volatile portions yielding gasoline, naphtha, and benzine, employed in motor cars, etc., while higher fractions flashing above 73 deg. F. form the kerosene, used for illuminating purposes. With most crude oils it is only the residue, which from American oil is called "residuum," and from Russian oil "ostatki," that provides fuel oil supplies.

Besides the American and Russian oil fields, oil has been found in almost all portions of the globe, but although the distribution is probably as wide as that of coal, the amount obtained outside the American and Russian fields is only about one-tenth of the total output. In addition to the natural petroleums, shale oil and the oil obtained from tar on condensation from the blast furnace can be obtained, but the present supply of these is so small as to be negligible.

Not only does the use of liquid fuel for marine purposes present great economies in labor and storage, but weight for weight it is, when properly used, of considerably higher evaporative power; and the following table gives the results obtained in practice with the same boiler, using various kinds of oil:

LIQUID FUELS.

	Specific Gravity.	Flash Point.	Calorific Value by Bomb.		Actual Evaporative Power from and at 212 Deg. F.
			Calories.	B. T. U.	
American Residuum	0.886	350	10,904	19,627	15.0
Russian Ostatki	0.956	308	10,800	19,440	14.8
Texas	0.945	244	10,700	19,242	14.70
Burmah	0.920	230	10,480	18,864	14.5
Barbadoes	0.958	210	9,899	17.718	14.2
Borneo	0.936	285	10,461	18,831	14.0
Shale Oil	0.875	288	10,120	18,217	13.8

The type of boiler used, fired with Welsh steam coal, would give as its maximum duty an evaporative value of about 9 to 10 pounds of water from and at 212 deg. F.

It is quite clear that if a national supply of fuel oil could be obtained which could be absolutely relied upon in time of war, the total replacement of coal in the navy by liquid fuel would not only be an enormous advantage, but would mean the saving of an annual consumption of a million tons of Welsh coal in the British navy alone.

By far the largest percentages of coal are used in factories and works where the coal is employed for the production of heat and power, and for these purposes it has now been realized that the gasification of the coal before use leads to such enormous economies that this procedure is almost universal in Germany, and has been adopted in many of the more up-to-date works in England, and the subject of power gas production is one of the most interesting of the day.

* Abstracted from a lecture delivered before the Society of Arts.

THE DA COSTA TWO-CYCLE GASOLINE ENGINE.

MOST of the two-cycle engines that are applied to automobiles are constructed on the same general principle. The explosive gaseous mixture is drawn into the cylinder either by a pump or by an ingenious mechanism placed below the piston. The latter device is adopted in the Legros and Peugeot motors, which contain neither independent pumps nor crank cases arranged to act as pumps, and which satisfy almost every requirement of two-cycle engines.

But the problem has been solved in a still better way by M. Da Costa, an engineer connected with the Cohendet establishment. Each cylinder of the Da Costa motor, which has recently been patented, has two concentric pistons which are connected with the same shaft by crank arms of unequal length and which consequently have different speeds and lengths of travel, though they move in the same direction at any given instant. The result is the formation of two separate chambers, of which one is used for admission and compression, and the other for explosion, expansion, and exhaust. Hence the action of a two-cylinder Da Costa motor is very similar to that of a four-cycle engine and the distinctive designation "four-two-cycle" has been adopted by the inventor. The diagram shows a vertical section of the motor at the moment when the two pistons of the left hand cylinder are at the lowest points and those of the right-hand cylinder are at the highest points of their respective strokes.

In the left-hand cylinder the descent of the inner, or compression, piston, *D*, has created a partial vacuum in the aspiration chamber, *F*, of the outer or working piston, *E*, and this vacuum is being filled by the inflow of gas from the annular supply chamber, *C*, through the ports, *B* and *B'*, which are now in line. As the two pistons ascend with unequal speeds the gas in *F* is compressed between the piston heads *H* and *G*. When the pistons have nearly reached the top of their strokes, the compressed gas escapes through the ports, *I*, into the fixed explosion chamber, *K*. Then the gas is ignited and the explosion drives down the power piston, *E*, which, on reaching the bottom of its stroke, uncovers the ports *L*, and allows the dead gases to exhaust into the annular channel, *M*. During the descent of the pistons a vacuum is again formed in the aspiration chamber, *F*, and the cycle of operations recommences. Leakage is prevented by three suitably placed rings on each piston and by staggering the ports so that ports *I* and *L* are not vertical in the same line, but are offset. The motor can be reversed with ease. It will not be put upon the market until it has successfully passed a series of severe tests.

LUBRICATION AND LUBRICANTS.*

THE CHEMISTRY OF OILS.

BY DR. P. MARTENS.

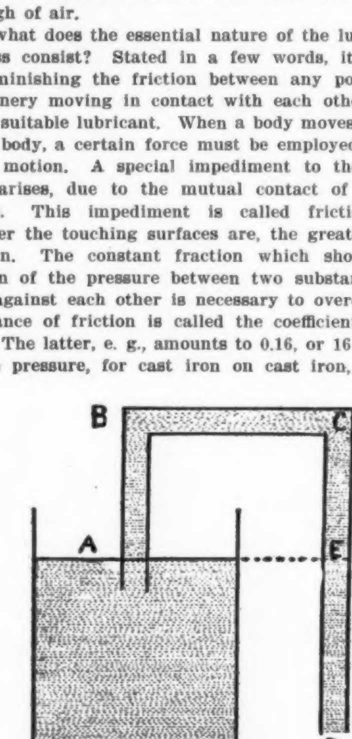
BEFORE the introduction of the various mineral lubricants prepared from petroleum residues, vegetable and animal fats and oils were exclusively used as lubricants. About the middle of the fifties the Galician oils were produced in such quantities that the Austro-Hungarian railroads were induced to make the first experiments with mineral lubricating oils. In Germany mineral lubricating oils did not come into use till the seventies, and in other countries till much later. Now mineral oils are almost exclusively employed as lubricants, vegetable and animal oils being employed only in exceptional cases and for special objects. The usual methods of investigation have rendered valuable service in adding to our general knowledge, but they seldom give an absolutely reliable answer to the question, what lubricant may be regarded as the best adapted for a definite purpose. Chemical analysis combined with practical experience can, however, bring about considerable saving in expense, especially in large concerns, by indicating, on the one hand, those lubricants which are most economical in their operation, and on the other, those which have the least injurious action on the parts of machinery to which they are applied, thus contributing to their preservation.

Mineral oils are obtained from the residues of earth oil (petroleum) distillates. After the lower-boiling constituents, benzine and illuminating oil (gasoline, naphtha, kerosene, petroleum) have been distilled off from the earth oil, there remain in the stills substances having a more or less glutinous consistency, often congealing at the ordinary temperature, dark green to black-brown in color and with a peculiar smell. These residuary products, called "masut" in Russia, are extensively used as fuel and also for preparing paraffin and lubricating oils. The thick easily congealing residues, such as those yielded by most American oils, contain paraffin in large quantities, while the residues liquid at ordinary temperatures, such as those derived from Baku oils, contain little or no paraffin.

The working up of the residues into lubricating oils consists in a re-distillation, usually performed at the present day by applying superheated steam and using a vacuum, followed by a chemical purification of the distillates. During the process of distilling, solar oil passes over first, having a specific gravity of 0.8855—0.890. As the process is continued, the specific gravity of the distillates, which are collected separately, is raised. After the solar oil comes the spindle oil, with a specific gravity of 0.890—0.910. Then follow the machine oils (S.G. 0.900—0.915) and finally the cylinder oils (S.G. 0.890—0.925). It need hardly be pointed out that the boiling points and consequently the flash points and burning points of the substances in question rise correspondingly.

The chemical purification of the distillates requires great care and skill, since each species of oil has to be treated in accordance with its peculiar properties. The following stages in the operation of chemically purifying the lubricating oil distillates may be distinguished: drying the distillates, treating the same with sulphuric acid and lyes, washing the neutralized oils and finally drying the washed oil. The object of drying the distillates is to free them from the water obtained through condensation from the superheated steam during distillation. This is done by gently heating to about 70 deg. C. by means of steam coils and with simultaneous blowing through of air. When the dried oil has cooled down to about 35 deg. C. it is treated with sulphuric acid and vigorously stirred in iron receivers. Then the greater part of the acid is separated by allowing it to settle and the oil first neutralized with soda-lye and finally washed with water. A small quantity of acid will always remain in the oil, but it must not exceed a certain limit, and it is very advisable when conducting an analytical investigation to determine the amount of acid present in the oil. The acid content, expressed in percentages of anhydrous sulphuric acid, must not exceed 0.03 per cent in cylinder and machine oil; 0.01 per cent is the maximum in dynamo or spindle oils. The subsequent drying process is again carried on in iron receivers provided with steam coils and with the aid of blowing through of air.

In what does the essential nature of the lubricating process consist? Stated in a few words, it consists in diminishing the friction between any portions of machinery moving in contact with each other by using a suitable lubricant. When a body moves over another body, a certain force must be employed to keep it in motion. A special impediment to the motion here arises, due to the mutual contact of the two bodies. This impediment is called friction. The rougher the touching surfaces are, the greater is the friction. The constant fraction which shows what portion of the pressure between two substances rubbing against each other is necessary to overcome the resistance of friction is called the coefficient of friction. The latter, e. g., amounts to 0.16, or 16 per cent of the pressure, for cast iron on cast iron, 0.15 for



WHAT MAKES THE SIPHON WORK.

cast iron on bronze, 0.20 for bronze on bronze. In other words, 15, 16, or 20 per cent of the total driving power is consumed in overcoming friction. The object of the lubricant, then, is to reduce this frictional coefficient and thus save work.

Lubricants not only diminish the friction arising from the motion of the lubricated surfaces, and thereby economize power which would otherwise be converted into heat, but they at the same time greatly reduce the wearing away of the rubbing surfaces, thus considerably prolonging the life of the machine.

As friction is due mainly to the fact that the protuberances of the one surface catch in the cavities of the other, motion can be kept up only if the moving body is repeatedly lifted over the projecting points of the body beneath, or if these projecting points tear or cut each other away. Friction is therefore diminished by inserting some slippery substance between the two bodies which equalizes the unevenness of the never perfectly smooth surfaces and keeps the latter apart, so that, strictly speaking, no actual friction takes place between the two metallic surfaces: only the relatively small interior friction of the lubricant need be considered. Consequently, the more firmly it adheres to the sliding surfaces, and the less its own interior friction, the more perfect is the lubricant. Heavy machines or heavily burdened axle bearings as a rule require refractory lubricants of high viscosity, as powerful pressure would press away a thinner oil and nullify the lubrication. Thin oils are more suitable for light and quick-running machines, while for rapidly revolving spindles, sewing machines, centrifugal machines and small dynamos the thinnest oils on the market are employed. The importance of determining the viscosity, which is generally performed with the viscosimeter, according to Engler, is therefore evident.

Another important consideration in determining the value of a lubricant for special purpose is its behavior when exposed to high or low temperatures. Cylinder oil, e. g., must possess good lubricating power at a high temperature without evaporating or giving off combustible vapors. A certain capacity of resistance to cold is requisite on the other, when the parts to be lubricated are exposed to great cold. For this purpose oils are required which remain fluid at the temperature in question.

Mineral oils, carefully selected, can be used for almost all kinds of purposes, and possess the advantage, moreover, of being very cheap. This does not mean, however, that other lubricants may not be found extremely valuable for particular purposes. Before the general introduction of mineral oils, glycerides, fatty oils, or fats derived from the animal or vegetable kingdoms were almost universally employed for lubricating. They are extensively in use even now, in spite of their high price, as they possess excellent lubricating properties, especially at high temperatures. They are, therefore, used, sometimes alone and sometimes mixed with mineral oils, for the high-pressure cylinders of locomotives and steamships. Even as ordinary cylinder oils mineral oils mixed with more or less fatty oil are frequently in demand, and a considerable saving is reported to result from their use.

Finally graphite has been lately used with excellent results as an added ingredient in lubricants. It is added to ordinary lubricants, such as fatty or mineral oils, in quantities of from 1 to 20 per cent (even 100 per cent with consistent fats). The tendency prevails at present to employ steam of very high tension or superheated steam, the temperature of which few of the lubricants commonly in use are able adequately to resist, and graphite is doubly valuable in these cases. For not only does it possess unusual lubricating power and remain unaffected by heat or chemical action, but considerable saving results from its use.

In several instances it has been found that an addition of graphite to the oil used heretofore in the respective concerns reduced the consumption of same to one-half or even one-third of the quantity used before. The wear and tear of the parts of machinery rubbing against each other is also greatly diminished.

* Pure Products.

WHAT MAKES THE SIPHON WORK.

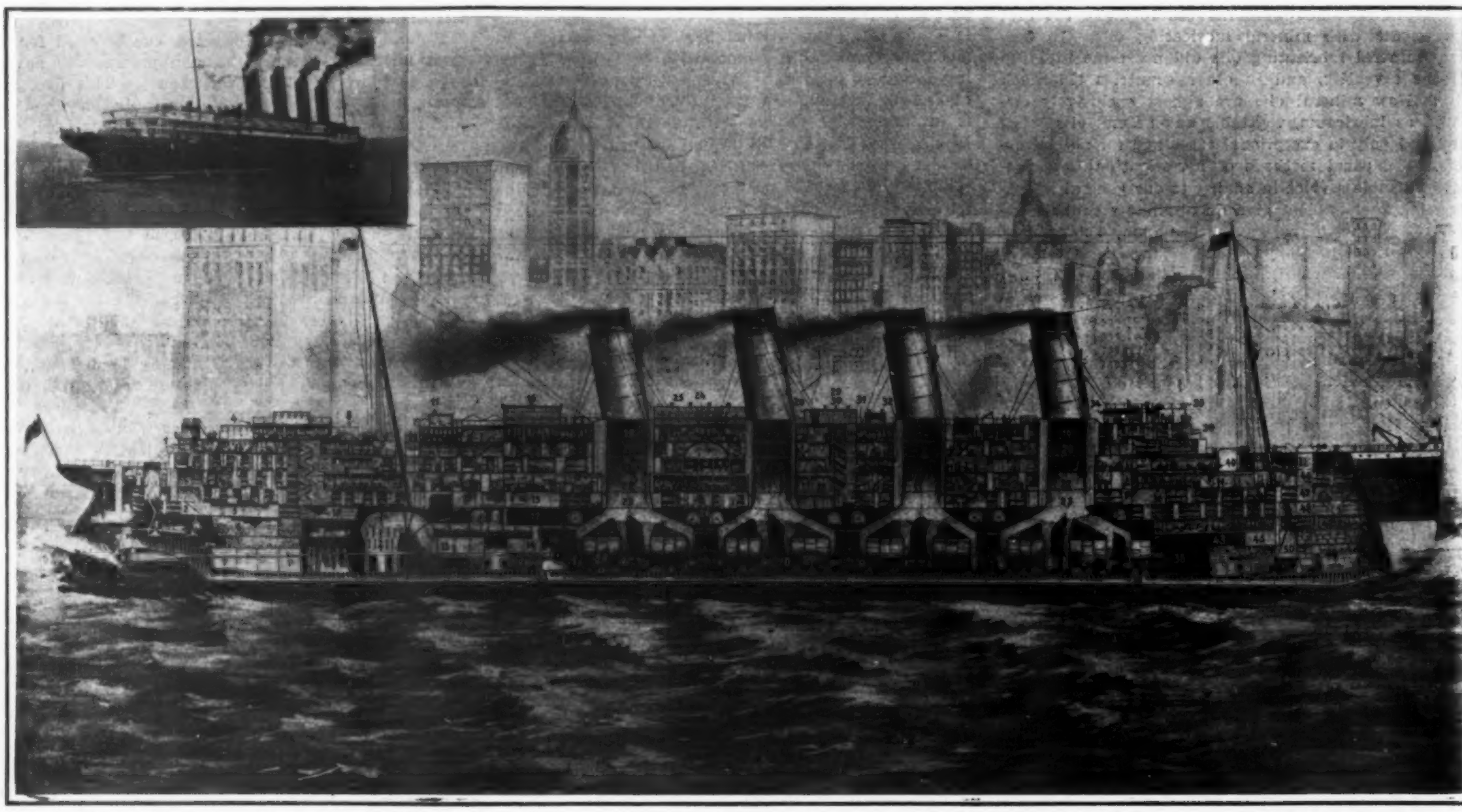
I HAVE noticed lately that a number of the current texts in physics give an incorrect explanation of the siphon. Seven out of fifteen such texts that I have examined state that the upward pressure in the short leg of the siphon at *A*, the level of the surface of the liquid, is equal to that of the atmosphere minus the pressure due to the column of liquid *A B*, also that the upward pressure at the bottom, *D*, of the long leg equals that of the atmosphere minus the pressure due to the column *CD*. It is clear that these statements are both incorrect. The upward pressure at *A* and *D* is, of course, that of the atmosphere, and the reason for the flow is, obviously, that the downward pressure at *D* is greater than atmospheric by the pressure due to the column *ED*.—School Science and Mathematics.

Commenting on the discovery of a new satellite of Jupiter last January by the Greenwich Observatory, Sir William H. M. Christie remarks: "The past year has been signalized by the discovery of a new satellite of Jupiter—very faint and very distant from its primary—as the result of close scrutiny of the series of photographs of Jupiter's sixth and seventh satellites, which have been taken at each opposition since their discovery at Lick Observatory in 1905. The circumstance that this very faint object has been detected at Greenwich and found on no less than twelve photographs taken since January 27, when it first came within the field covered by the plates (taken to show the seventh satellite in the center), is a testimony to the assiduity with which the observing staff watch for every favorable opportunity for a long exposure, and also to the suitability of the Greenwich climate for the observation of very difficult objects, such as faint satellites and close double stars."

THE ANATOMY OF THE "MAURETANIA."

A LONGITUDINAL SECTION OF A GREAT SHIP.

THE new turbine Cunard liner "Mauretania" is even more luxuriously appointed than her sister ship, the "Lusitania." The "Mauretania" is 790, the "Lusitania" 785 feet in length. The internal arrangement of the "Mauretania" is shown in the longitudinal section here given.



1. Second-class smoking room.
2. Lower deck.
3. Steering engine.
4. Second-class promenade and saloon.
5. Mail sorting room.
6. Baggage room.
7. Fresh-water tanks.
8. Second-class dining room.
9. Second-class saloon.
10. Mail bags.
11. Café.
12. Kitchen.
13. Forward turbine.
14. Backward turbine.
15. Heating apparatus.
16. First-class smoking room.
17. Engine rooms.
18. Engineers' starting platform.
19. Sun deck.
20. Promenade deck.
21. Upper deck.
22. Saloon deck.
23. Main deck.
24. Grill room and music room.
25. First-class dining room.
26. Ventilators.
27. Boilers.
28. Marconi station.
29. Staircase.
30. Passenger elevators.
31. First-class reading room.
32. First-class children's play room.
33. Ballast tanks.
34. Officers' quarters.
35. Bridge.
36. Third-class dining room.
37. Third-class quarters.
38. Coal bunkers.
39. Captain's cabin.
40. Third-class smoking room.
41. Third-class quarters.
42. Cold-storage rooms.
43. Baggage room.
44. Cargo.
45. Fresh-water tanks.
46. Stewards' cabins.
47. Crew's quarters.
48. Lower deck.
49. Cargo.
50. Chain well.

THE ANATOMY OF THE "MAURETANIA."

A TWENTY-FIVE YEAR RECORD IN BRITISH AND AMERICAN IRON CENTERS.*

THE Iron and Steel Institute revisited the famous Cleveland District in England, this year being the twenty-fifth since its last meeting at Middlesbrough. A review of the district's progress in iron and steel in a quarter century was presented in a paper by W. Hawdon. While it shows a real advance, it is like all the statistical exhibits of the British iron trade in the past two decades or more, in having none of the sensational contrasts that make American iron trade statistics really fascinating. As the leader in pig iron and open hearth steel production in Great Britain, the Cleveland District may be compared with the Pittsburg District in the United States, by way of bringing out the contrast between the pace at which the iron industry has advanced in this country and the rate of development which may be taken as the British standard. As the paper before us goes back to 1883, the comparison with the Pittsburg District is particularly opportune, since that was the year in which Allegheny County passed the Lehigh Valley and took the lead in pig iron production in the United States. In the statement below we show the production of pig iron and steel in the two districts at the beginning and end of the twenty-five-year period in gross tons.

	1883.		1907.	
	Pig Iron.	Steel.	Pig Iron.	Steel.
Cleveland Dist. (Eng.)	2,760,740	314,606	3,534,068	1,749,347
Pittsburg District....	528,996	302,080	5,438,233	6,905,590

Expressing the growth of production in the two districts in percentages, the contrast is presented of an increase in pig iron output in the Cleveland District of 28 per cent in the 25 years, while in the Pittsburg District the increase in the same period was 928 per cent. The showing in steel is naturally more striking, since it represents not only the growth of an important period in the world's industrial development, but the revolution due to the converter and the regenerative furnace. As against 456 per cent increase in steel for the Cleveland District there is a gain of 1,808 per cent for the Pittsburg District.

Leaving these contrasts in growth, which are first suggested by Mr. Hawdon's paper, some of its statements concerning the Cleveland District are worthy of attention. The Cleveland iron ore production of 1883, it is a surprise to note, was the greatest on record—6,756,055 tons. In 1893, when steel had begun to replace manufactured iron, and foreign ores were being imported by the district for the production of acid steel, the demand for Cleveland pig iron for puddling fell off, and the lowest point in Cleveland iron ore production in the past thirty years was touched, at 4,625,530 tons. The development of basic open hearth steel manufacture in the Cleveland district, as shown by a production of 139,784 tons in 1903, and 416,207 tons in 1907, turned the tide in favor of native ores, and last year the ore production was 6,220,000 tons, or still 500,000 tons less than in 1883. Two causes have operated to prevent the Cleveland iron and steel companies from getting a sufficient supply of native ores. One is the gradual thinning of the ore seams and the necessity of carefully extracting shale and sulphur. The other is the action of the miners, who, when trade is good and wages high, cut down their daily output. It is worth while to note what the writer of the paper says on this point, as it is typical of British trade union procedure, and has its bearing on the tameness of the quarter century's statistical showing:

"One is bound to ask, Why not put more men on? The reply in part to this is that the miner, when being taught his trade, cannot 'get' so much stone, and therefore of course cannot earn what is known as the average of the district, and when this happens a pretext is apt to be made by the miners' officials for an increase in the price per ton for getting the stone. The manager is thus between the devil and the deep sea; he wants more stone, but he cannot get it without paying a price which he cannot afford to give, and therefore hesitates to put on labor which has yet to be taught to be efficient. This is a curious incident when taken in connection with the unemployed problem, and apparently helps to maintain the army of unemployed, whereas the demand for more miners ought to afford an opening for their employment. Whatever the cause, the fact remains that, with the present demand, we are supplementing our supplies by using more foreign ores, and ores from other districts, for mixture with Cleveland ore, to keep pace with the demand. This of necessity increases the cost of production of Cleveland pig iron."

It is hard to imagine what would have been the state of Lake Superior iron mining to-day, or of the American steel industry at large, had its development been contingent upon the consent of such a type of labor unionism.

In reference to the power economies which are assuming prominence in all iron and steel operations, the paper notes that gas utilization is coming on slowly. In but few cases are blast furnaces and steel works found in conjunction, and fuel is so cheap that the saving in coal would not compensate for the installation of gas engines and gas cleaning plant. It is interesting to find, however, that in the way referred to in a paper printed elsewhere in this issue, a public electric power company is buying the exhaust steam from the Cleveland blast furnace blowing engines, and utilizing it in low-pressure turbines to develop electric power of high tension. This method of making use of waste steam, and also of gases from blast furnaces, promises to develop into large proportions in this historic iron making center of Great Britain.

* Iron Age.

An investigator has discovered that a mixture of the following ingredients forms an acid-resisting cement for tanks, floors, etc.: Silicate of soda, 6 parts (water glass); glycerin, 1 part; red lead, 3½ parts; fine cinders, 10 parts.

The silicate of soda and glycerin are mixed and then the red lead and cinders added to make a mass resembling putty. This is used for the cement. It soon sets or hardens, and when heated to the temperature of boiling water, unites with brick or Portland cement to form a strong joint.—The Brass World.

MARKINGS AND COLORS IN FISH.*

HOW THEY PROTECT THEIR WEARERS.

BY FRANCIS WARD.

STONE LOACH IN AN UNNATURAL POSITION.

STONE LOACH IN A NATURAL POSITION.

Few members of the animal kingdom have so many enemies as the fish. Preyed on by man, beast, and bird, devoured by their own kith and kin, the balance in fish-life would not be long maintained if it were not for the facts that fish are so prolific, and that they possess in a greater degree than any of the higher vertebrata the power of changing their color and markings, so as to simulate their surroundings. These changes in color and markings are brought about by the alteration in size and arrangement of the numerous pigment cells present in the skin of the fish. First we have the slow changes that occur in fish which for generations have occupied surroundings of a similar nature, e. g., the stone loach. This fish is usually found on the gravelly bed of a rippling stream, and the pigment cells have become so arranged as to resemble the mottled markings on the stones. In the first photograph, that of a loach perched on a stone, the protective arrangement of the pigment cells is shown on the body, tail, and fins; as this fish usually rests on the bottom, the under surface requires no protection, and so is devoid of dark pigment cells. It was a long time before the stone loach could be induced to lie in such an exposed position, and very soon he swam off, taking up his quarters as shown in the second photograph. Some fish, e. g., the trout, are to be found in localities of very different natures. In the case of trout inhabiting dark deep waters, the black pigment cells slowly increase, and the red and yellow disappear, the converse being the case with trout found in a clear running stream with a gravelly bottom.

HEAD IN DARK CHAMBER.

Again, the young pike has numerous yellow bars across his body, these bars so much resembling the stems of the reeds among which he lies that he is almost invisible. As the pike grows stronger and bigger there is not the same risk of his being devoured, and so he moves out into the more open water, the markings at the same time altering so as to suit his new surroundings, by the yellow pigment cells disappearing at regular intervals along the bars across the body, the stripes of the young fish being thus converted into the spots of the adult fish. The above changes, like all developments, are gradual, but in addition fish have the power of becoming rapidly light or dark, according to their surroundings, by the rapid contraction or relaxation of already existing pigment cells.

Some years ago I heard of several trout that were turned into a stream; of these the majority were bright and light in color, but a few were found to be quite dark; these dark fish were blind. The supposed explanation was that light through the optic nerve caused a reflex stimulation of the nerve endings in the skin, resulting in a contraction of the dark pigment cells, and so the healthy fish were light in color. This stimulation being absent in the blind fish, the dark pigment cells remained relaxed, the fish in consequence being dark in color. To prove this theory I made the following experiment with a healthy pike that I happened at the time to have. I obtained a wooden tank, 4 feet long and 6 inches deep. The bottom and sides were painted with white enamel. Across the tank I placed a partition, with an arch cut out of the bottom of the partition sufficiently large to admit the body of the pike, the arch being in contact with the bottom of the tank. On one side of the partition the tank was left open, on the other side it was covered up so as to form a dark chamber. The pike was first placed with his head in the dark chamber, the body and the tail being in the light, sufficient water having been put in the tank just to cover the fish; he remained in this position, in bright sunshine, for two hours, and it will be seen in the photograph that the parts exposed to the light are quite dark, and no markings are visible. The fish was then turned round, and in three minutes a second photograph was taken. The markings were now quite distinct, and the pike appeared lighter in color than even the photograph represents it.

The above experiment proves beyond doubt that light does not directly cause a contraction of the pigment cells, and, taken in conjunction with the incident of the blind fish, it proves that the stimulus which causes contraction of the pigment cells is received through the eye. There appeared to me, however, to be some doubt as to the means by which the light stimulus received by the eye was conveyed to the pigment cells. It might be, as already mentioned, a reflex stimulation of the nerves supplying the skin,

HEAD IN THE LIGHT.

* Country Life (London).

PIKE. BARS CHANGING TO SPOTS.

GUDGEON, SHOWING LATERAL LINE.

or the stimulus might be conveyed by the numerous nerves running in a duct described in the next few lines, and thence to the skin. Down each side of a fish runs, from the head to the caudal fin, a series of perforated scales. This line of perforations is known as the lateral line. The perforations in the scales communicate below with a duct, which, commencing in the bones of the skull, just below the eye, runs down each side of the body and tail to the caudal fin. The main function of this duct is undoubtedly to secrete mucus to lubricate the fish, and thus let him slip easily through the water; but in it also run numerous nerves, and commencing, as this duct does, close to the eye, it was possible that the nerves in this duct might influence pigment cell contraction. It is only recently that I have convinced myself that this is not so.

A big pike was brought to me which had been badly gaffed; the duct below the lateral line was torn, and the wound extended through the skin toward the back. This fish had been caught about six hours, and appeared to be dead. He was placed in a large bath, the water was thoroughly aerated round his head with a bicycle pump, and weak whisky and water was poured down his mouth every ten minutes. Gradually the fish revived, and I left him lazily swimming in the bath. Next morning the skin of the pike was quite light in color, owing to the bath being painted white, except for a dark triangular patch on his side, the base of the triangle being the wound made by the gaff. Beyond the patch the fish was light in color; proving that the nerves in the duct below the lateral line do not control the contraction of the pigment cells, and that it was merely the division of the ordinary cutaneous nerves that caused the dark triangular patch. These facts are probably well established, but the demonstration of them by photography may be new to some of the readers of Country Life who are interested in fish.

FORCING PLANTS BY WARM BATHS.

A NEW METHOD OF ACCELERATION.

BY HANS MOLISCH.

About twenty-five years ago I saw in Vienna an exhibition of flowers and fruit representing the four seasons. The collection included blooming primroses, hyacinths, narcissuses, daffodils, tulips, balsams, poppies, mignonette, verbenas, asters, and dahlias in addition to cherry, apricot, peach, and winter pear trees and a grape vine, all bearing ripe fruit.

The labor and experience involved in producing an exhibit like this can be appreciated only by the professional horticulturist, but even the amateur knows that many plants require occasional periods of rest.

If a cherry branch is cut in October, after the leaves have fallen, and placed in a warm room or a hothouse, its buds do not open. In order to grow it requires not only conditions favorable for growth, but also a long preliminary rest, preferably in the open air in winter. Long experience has taught horticulturists how to make themselves to some extent independent of the seasons and to produce many flowers and fruits at unnatural seasons. These results are accomplished by breeding the so-called "forcing varieties," by shifting the period of rest, by depriving the plants of water and by other methods.

The rest periods of plants have been studied by scientific investigators, who have given practical horticulturists valuable suggestions which have led to the shortening or entire elimination of the period of rest. The long winter sleep of potatoes, for example, can be replaced by exposure to a temperature just above freezing for two weeks immediately after the potatoes are harvested. The Danish botanist Johannsen discovered that the growth of plants is stimulated by ether. Branches of lilac and other shrubs begin to grow immediately after exposure to ether vapor for a day or two during their natural period of rest.

I will now describe a new forcing process, which was first used by practical gardeners in forcing lilacs and maybells and which I have investigated.* This new method, which for brevity I will call the warm bath process, consists in soaking cut branches or rooted plants of various trees and shrubs in water at a temperature between 68 and 86 degrees F. for from 9 to 12 hours and then cultivating them in the usual manner. The process is applicable to the hazel (*Corylus*), lilac (*Syringa*), *Forsythia suspensa*, dogwood (*Cornus alba*), gooseberry (*Ribes grossulana*), larch (*Larix decidua*), black alder or buckthorn (*Rhamnus frangula*), horse chestnut (*Aesculus hippocastanum*), willow (*Salix*), etc. I give some examples of the application of the process and its results:

Example 1.—On November 19, 1907, three freshly cut branches of *Forsythia suspensa* were immersed for 12 hours in water, the temperature of which varied between 77 and 90 deg. F. They were then placed in the hothouse, with their cut ends in water, together with three other branches which had not been immersed in hot water. Twelve days later the treated branches were in full bloom, but all of the buds on the other branches still remained closed.

Example 2.—The top of a rooted lilac bush was immersed for 12 hours in hot water (88 to 98 deg. F.) and the bush was placed in a moderately warm forcing house (59 to 64 deg. F.) Forty days afterward the bush was in full leaf and flower, but the buds of another lilac bush, which had been treated similarly with the exception of the warm bath, were just beginning to open.

Example 3.—This and the following example strikingly illustrate the local effects of the warm bath. A hazel stem with a number of branches bearing very young and small catkins was half immersed in hot water, so that some of the catkins remained dry. The duration of the partial immersion was 12 hours, the temperature of the bath 77 to 86 deg. F. Six days later the bathed catkins had attained their full development and were many times larger than they were before the bath, but the unbathed catkins showed no perceptible change.

Example 4.—A similar experiment was performed with *Forsythia suspensa*. Nineteen days after the bath the bathed branches were in full bloom, but the buds of the other branches remained closed.

Still more strikingly than the strictly local character of the influence of the warm bath is the fact that it remains so long undeveloped or latent. If the bathed branches or plants are not placed at once in the forcing house but are first exposed to the open air for two, three, or four weeks in ordinary autumn or winter weather and are then cultivated in the hothouse, they behave precisely as they did in the cases described above, in which they were put into the hothouse immediately after the bath.

The successful employment of the warm bath process is dependent on the nature of the plant, the condition of the buds, the season, and especially the following circumstances:

a. The duration of the bath. In general an immersion of from six to twelve hours is sufficient. It is seldom advisable to prolong the bath beyond twelve hours because the high temperature increases the demand for oxygen, the free access of which is prevented by the water. In these conditions the normal respiration is checked and sometimes replaced by intramolecular respiration, which, if it continues too long, may injure or even kill the buds.

b. The temperature of the bath. The same temperature is not suitable for all plants. The hazel, *Forsythia*, gooseberry, and lilac are sufficiently stimulated by a bath at 86 deg. F., but a temperature between 95 and 104 deg. F. is better for the horsechestnut, and necessary for the dogwood, buckthorn and birch.

c. The depth of the winter sleep. Some plants are influenced by a warm bath given immediately after the fall of the leaves in autumn, but to other plants the bath must be given later. Branches of horse chestnut and ash grow vigorously after a warm bath in December or January, but are not affected by bathing in early autumn. Toward the end of the winter sleep the effect of the bath gradually diminishes. At the end of the natural period of rest the warm bath may even retard growth, as I have frequently observed in the hazel and *Forsythia*.

Of especial interest is the curious fact that the warm bath affects leaf buds and flower buds very differently. A bath in autumn produces an immediate and striking effect on the male catkins of the hazel, but none upon the leaf buds, which naturally open later than the catkins. Not until January does the warm bath stimulate the leaf buds. Their sleep appears to be far deeper than that of the flower buds and the warm bath can have no effect upon them until the chemical process, which goes on during the period of rest, has reached a certain stage.

The warm bath process gives florists another new method of accelerating the blooming of lilacs, maybells, azaleas, *Forsythia* and other plants. Excellent results have been obtained with Johannsen's process of etherization, but the warm bath process appears preferable in practice, because of its cheapness, simplicity, and safety.—Umschau.

* For a fuller account see Sitzungsbericht der Kaiserliche Wiener Akademie, Band xvii, Abteilung 1, 1906, No. 87.

COMBINED OPTOMETER AND ENTOPTISCOPE.

Prof. W. F. Barrett, F.R.S., of Dublin, has devised a "new form of combined optometer and entoptiscope." The entoptiscope enables us to see things in our eyes, and his instrument, Prof. Barrett explained, enabled everybody to examine his own eye, while the ophthalmoscope was the instrument which the oculist used for examining the eyes of patients. The principle of the entoptiscope was that of pin-hole vision; the method had been discovered seventy years ago by Listing and Donders (of Utrecht), but had been discarded in favor of the ophthalmoscope. The instrument was most simple. A screen of ground glass was illuminated by a mirror from below; above it was mounted, on a stand provided with a head-rest, a diaphragm, one for each eye, to be rotated by hand; a series of pin-holes of different diameters were arranged in a circle in the diaphragm. The light entering the eye from below formed shadows of any specks on the cornea or matter floating in the liquor. The nodal point was in most eyes immediately (about 0.1 millimeter) behind the crystalline lens, 16 millimeters in front of the retina. The observer hence saw an enormously magnified shadow, and could draw this himself on the screen with the aid of a pencil.

With this entoptiscope we could also discern the irregular radial structure of our crystalline lens and watch the condition of our eyes after hard work. We could further determine the refraction error in our eye, and the "ocular parallax" discovered by Brewster and not fully explained so far, which, Prof. Barrett suggested, depended upon the magnitude of the pupil and the distance of the object. By adding a lens and a slightly silvered mirror to the instrument, such that the rays from the object passed through the mirror, and the rays from the test-card were reflected by it in the same direction, the instrument became an optometer. It could also be used for determining astigmatism, and for comparing color intensities, by making the comparison ray pass through a solution of Indian ink and watching for the extinction of the light.

THE STANDING TIMBER OF THE UNITED STATES.

The National Conservation Commission has caused the first comprehensive attempt at a census of the standing timber in the United States ever undertaken. The Forest Service has for several years been eager to take such a census, and the Bureau of the Census has expressed its willingness to co-operate, but funds have never been available. The conservation commission, however, needs the information to help complete its inventory of the country's natural resources, which it will include in its report to the President, and since that report is to be submitted on the first of next year, it needs the information at once. Large portions of the forests of the country, including practically all the national forests, have been estimated at various times, but these figures have never been brought together and no organized effort has ever been made to gather them into one total, nor to supply the deficiencies where hitherto no estimates have been made. As a result, the guesses as to the amount of standing timber in the United States, range from 822,682 million to 2,000 billion board feet. In the opinion of the Forest Service, the most carefully prepared estimates yet made are those by Henry Gannett, published by the Twelfth Census in 1900. These placed the total stumpage at 1,390 billion board feet. Mr. Gannett has been chosen by the president to compile the information gathered for the commission, and with his previous acquaintance with the subject of forestry, he is at work now enlarging the knowledge of forest areas at present available. The importance of this census lies largely in the fact that it will give an accurate basis for computing how long our timber supplies will last. Through the co-operation of the Forest Service and the Census Bureau, the country's annual consumption of wood is known with tolerable accuracy, although even here there are some discrep-

ancies, because a large amount of wood is used for posts, fuel, and domestic purposes, for which no satisfactory data have yet been collected. But the consensus of opinion is that the present annual consumption is about 100 billion board feet, or something more than that. One leading authority has placed it as high as 150 billion board feet. Assuming a stumpage of 1,400 billion feet, an annual use of 100 billion feet, and neglecting growth in the calculation, the exhaustion of our timber supply is indicated in fourteen years. Assuming the same use and stand, with an annual growth of 40 billion feet, we have a supply for twenty-three years. Assuming an annual use of 150 billion feet, the first supposition becomes nine years, and the second thirteen years. Assuming a stand of 2,000 billion feet, a use of 100 billion feet, and neglecting growth, we have twenty years' supply. Assuming the same conditions, with an annual growth of 40 billion feet, we have thirty-three years' supply. With an annual use of 150 billion feet, these estimates become, respectively, thirteen and eighteen years.—Science.

THE PRACTICAL VALUE OF BIOLOGY.

WHAT BIOLOGY HAS DONE FOR US.

BIOLOGY has to explain the nature of living energies in treating of animals and plants and of man himself. Biology has to interpret processes, and this it attempts to do in a variety of ways according to the nature of the problem, the material and the bias of the thinker. Biology has to some extent grown up side by side with medicine; each helped the other in the days of their beginnings, and for that reason we may first treat its practical bearings to medicine.

In the seventeenth century the microscope came into use and it opened up, in the hands of Leeuwenhoek and Schwammerdamm, a wealth of unexpected detail. Leeuwenhoek exhibited his dissection of an ant to the delighted eyes of a king; since that time the tastes of royalty seem to have deteriorated. But such discoveries in the finer details of anatomy only presented new problems. The partial explanation came in 1838 with Schleiden and the following year with Schwann, who stated that animals and plants are built up of definite living units, the cells; that such units compose the tissues that had been determined by the physiologist Bichat, and that the organs are composed of definite layers of cells. The simplest animals, what we now call the Protozoa, were shown by Dujardin to be each composed of only a single cell. We define a cell as a particular mass of living substance regulated by a particular center, the nucleus. This view was strengthened by the notable researches of particularly Von Kölliker and Max Schultze, and so gradually extended to all animals and plants as well as to the human body. Eduard van Beneden later finally settled the fact that the egg, the beginning of each many-celled animal, is itself a single cell. Thus biologists have come to concentrate their attention upon cell activities, and this cell unit has proved as fruitful in biology as the atom in chemistry, though the cell is something vastly more complex than many atoms. Now there grew up with this new doctrine Rudolf Virchow, the great master of the study of disease, and he it was who by placing the study of disease upon the cellular basis, by tracing diseased conditions to particular cells, laid the rational foundation of one branch of modern medicine. The investigation of the structure and function of cells is to-day regarded as the basis of research in medicine as well as in biology. Yet all of it is traceable to the dissection of an ant beneath a crude microscope! Surely nothing would have seemed less likely to have had practical bearings.

Such studies have given also the basis for embryology, the analysis of the development of the individual. Perhaps the greatest marvel of nature is the growth and change of the individual, a process that is ever before us, yet considered by few. From a microscopic egg cell that shows but few differences in its various parts, grows up the adult body with its manifold organs; hairs and muscles, bones and lungs, these are not present as such in the egg cell, yet they gradually arise out of it and in the order of their use. The problem is: is such development regulated by energies of the egg cell, or by the operation of new stimuli and energies as the development proceeds? The marvel is the astounding precision of the process in spite of its complexity. When you eat your morning egg glance at the yellow yolk ball and note at one point of its surface a small white disk; that is the egg cell proper, all the rest is simply food for it. Now try to think out how that little disk produces the complex fowl, and you will agree that the problem is a much harder one than the fluctuations of stocks in your morning paper. This problem has also a close bearing on medicine, as William Harvey pointed out some three centuries ago and more, for the development of the human body is as important to the physician as its anatomy, because the anatomy is but one view of the individual, while the development represents the whole. To understand our own bodies we must know how they are formed, and to understand disease it must be traced to its origin. The changes from the egg cell to the adult demonstrate that the longer a part develops, the more precise and fixed it becomes, so that finally each particular part comes to have one definite structure, position, and use. Malignant growths, then, probably have their causes most frequently early in development, due to misplacement of cells, temporary arrest of growth, undue rapid multiplication of cells, and other abnormalities. But this is not the place to attempt to classify diseases on an embryological basis, such as has been done by Minot. We need note here only that medicine is beginning to tread in the path made by biology, in recognizing that human disease as well as human anatomy must rest on the foundation of development.—Prof. Thomas H. Montgomery, Jr., in Popular Science Monthly.

MANGANESE BRONZE.*

THE best present-day alloys of manganese bronze are the results of years of scientific research by several of the largest manufacturing concerns, which maintain chemical and physical testing laboratories in connection with their brass foundries. Of all the metal industries brass founding is almost the last to pass from the empirical and rule of thumb to a scientific metallurgical basis. In fact, the majority of the brass and bronze manufacturers have never used chemical analysis or a testing machine, and therefore have only a general idea of the composition and physical properties of their products. But conditions have changed, or are changing, and engineers have multiplied power and manipulated pressures beyond all former figures. Machinery is more powerful, more complicated, and more severely tested than ever before, and while the steel and other industries have made great advances and kept pace with requirements, the same rate of improvement has not been maintained in copper and brass, except in the case of the high tensile strength of manganese bronzes. Manganese bronze first found its important practical application in the manufacture of propeller wheels for ships. Now cast iron and cast steel have been almost universally displaced by it, not only for all naval vessels, but the merchant ships of the world have adopted it as standard practice. Marine engines have been increased to such vast powers that 20,000, then 40,000, and now 70,000 I. H. P. are transmitted through manganese bronze propeller wheels. In such ships the speed runs upward of 300 revolutions per minute. There is no metal of equal strength and toughness which will produce such sound, smooth, and intricate castings, true to the form of the pattern. These qualities permit of the maximum fineness of section of the propeller blade, and at the surface speeds of thousands of feet per minute friction is reduced to a minimum. This bronze is practically incorrodible in sea and alkali waters. Likewise dilute acids and acid mine water are withstood successfully. Cast blocks of manganese bronze immersed for one year in the most acid mine water in Pennsylvania, containing about 300 grains of sulphuric acid per gallon, showed no material corrosion, and a test piece cut from this metal showed no diminution in tensile strength from that of a duplicate specimen previously tested.

Testing Methods and Results.—Test pieces cut from cast propellers should show an average ultimate tensile strength of 70,000 pounds per square inch, elastic limit of about 35,000 pounds, ore one-half the ultimate; a 25 per cent elongation in 2 inches and 25 per cent reduction. The reduction of area follows the elongation closely in cast manganese bronze. These figures can be varied to suit requirements. A soft manganese bronze having an ultimate strength of 60,000 pounds per square inch and 40 or 50 per cent elongation in 2 inches is the lower limit, while an exceedingly hard manganese bronze can be made to test over 90,000 pounds per square inch, with even as much as 30 per cent elongation. The methods of testing manganese bronze physically do not differ materially from the standard methods for steel. Test pieces according to the standard United States government sizes, 0.505, 0.798, or 1 inch in diameter, are machined 2 inches between punch marks and threaded. In the case of castings there is not a sharply defined elastic limit, and the yield point cannot be determined by the drop of the beam. Multiplying dividers or a standard extensometer will establish quite closely the point at which an appreciable change in the rate of strength takes place. In the case of rolled or forged manganese bronze the yield point is more closely defined, and the elastic curve is frequently sharp enough to detect the drop of the beam or a halt of the gage wheel. In compression cast manganese bronze, if properly made, shows an average elastic limit of 35,000 to 40,000 pounds per square inch and a maximum crushing load of 90,000 to 100,000 pounds per square inch. Rolled or forged manganese bronze tests 50,000 to 60,000 pounds elastic limit, and as high as 130,000 to 150,000 pounds maximum crushing load.

Rolling and Forging.—Manganese bronze can be rolled or forged readily at a red heat with the production of an exceedingly tough, dense, and close-grained metal. Microscopic examination of cast manganese bronze after polishing and etching reveals a very homogeneous and uniformly-grained metal, but after rolling or forging to a sufficient reduction the structure is reduced to from 1-30 to 1-50. Rolling or forging raises the proportional elastic limit to from 45,000 to 75,000 pounds per square inch, depending upon the finishing temperature and the amount of work done on the metal. Likewise the ductility and toughness are increased, but without a corresponding increase in ultimate strength. Forged and rolled rods find a wide application as piston rods, shafts, axles, and for all purposes where a metal of equal strength and toughness to carbon steel is desired, and which will not rust or corrode in the atmosphere or in mine or sea water. An especially soft and tough metal is made to resist vibratory and sudden stresses and shocks. It is used under very severe conditions in modern naval ordnance. Another application is in staybolts for locomotives. This bronze tests 40 to 50 per cent elongation, with about 60 per cent reduction of area.

The Demands of Electrical and Automobile Service.—Thus only a few of the better known applications of manganese bronze have been pointed out. The electrical industry is calling for it for turbo-generator sets, which are run at speeds up to 4,000 revolutions per minute, and the blades of the steam turbine are satisfactorily made of extruded manganese bronze shapes. In this case the erosive action of high-pressure steam is severe, and under it most metals fail. The infant industry, which has grown to such lusty proportions in this country, automobile manufacture, has set a very high standard for materials demanded by its peculiarly hard service conditions. Automobiles with gasoline motors of 60 horse-power, and even as high as 130 horse-power, at speeds of 1,000 to 1,500 revolutions per minute, and running over all kinds of roadbeds at 60 and 100 miles an hour, have stimulated the improvement of the materials entering into their construction more, perhaps, than any other modern machine. The nickel-chrome and other high-grade steels in gears and drop forgings have produced results never heard of before, and cast iron has been wonderfully improved by the requirements of automobile cylinders. Likewise manganese bronze formerly used almost exclusively in warships has been adapted to produce forgings and castings which will not crystallize or fail under similarly severe conditions.

* Abstract of a paper read before the American Society for Testing Materials, by Mr. C. R. Sparc.

A NEW ALLOY.

A NEW alloy which has been brought out in France and is known as "Invar," has the valuable property of having practically no expansion, and is thus adapted for various purposes. M. Guillaume succeeded in forming such an alloy in connection with the Commentry-Decazeville metallurgical firm. Nickel steel is the base of the alloy, and up to 20 per cent of nickel, the expansion is about the ordinary. It then increases up to a value of 24 per cent, reaching a minimum value at 36 per cent of nickel, then rising and taking the normal value for a 50 per cent alloy. It is the 36 per cent metal which has the curious properties brought out by M. Guillaume, and its expansion is almost zero, being 17 times less than that of steel and about the same as for melted quartz. The new steel is not magnetic and it does not rust. Owing to these properties, it is already used at Paris and elsewhere in the construction of spiral springs, pendulums, graduated scales for instruments. Its field of useful-

ness is extensive, and it can receive many applications where these properties are needed. One valuable application is in the formation of standard measures such as the meter, and different standard scales have been made at Paris by the International Bureau of Weights and Measures. Such scales or gages are remarkably exact, owing to the non-expansion of the metal. They are used in the artillery works at present, and very precise work can be carried out with the gages and calibers, diminishing the errors which were found previous to their use. According to the tests made upon standard scales, these hold their value within a remarkably small percentage. By varying the amount of nickel in the combination, a second alloy can be formed which is valuable as having the same coefficient of expansion as glass, and it can thus be used to replace platinum in the leading-in wires of an incandescent lamp, thus reducing the cost of these wires to a comparatively low figure. It can also be used to replace the platinum wires of eudiometers and Geissler tubes for the same reason.

WORKING COST OF THE RENARD ROAD TRAIN.

THE ECONOMY OF A COMMERCIAL AUTOMOBILE.

BY OUR PARIS CORRESPONDENT.

We have from time to time described the gasoline motor-driven road train invented by the late Col. Renard, but it has not been until recently that any reliable working costs of the system under general commercial conditions have been available. Now, however, a firm of carrying agents in Antwerp, who adopted the system on trial for the transport of freight between the docks and warehouses in the city, has published the results of its efforts, which are of greater interest and value, seeing that the mechanical road system was working side by side with similar horse-drawn traffic.

The daily expenses attending the operation of the train are fully set forth; but it must be pointed out that the train was only running over short distances in the city and environs, making a high percentage of stoppages for loading, unloading, passing traffic, and so forth, so that possibly the expenses are higher than they otherwise would be if the service were simply confined to working between two defined points at a greater distance apart.

Gasoline, 17.5 gallons at 26 cents per gal.	$4.20
Engineer per day	1.00
Assistant per day	.68
Repairs, 2½ per cent on capital of $9,280 (300 days to the year)	.77
Depreciation at 20 per cent on motor (300 days to year)	3.83
Depreciation on two followers at 20 per cent (300 days to year)	2.33
Lubrication and sundries	.50
	$13.51

The working costs per ton-mile of a train made up of one motor and two trailing vehicles, the motor carrying 10 hundredweight and the two followers each carrying 4 tons, making 8½ tons total load, upon a basis of 32 miles per day represents 272 ton-miles, which divided into the total running expenses per day gives $4.96 per ton mile, this representing five round trips per day. On a day's work of six round trips totaling 38.4 miles, involving an additional expenditure of 75 cents for gasoline consumed on the extra journey, the working expenses per ton-mile averaged 4.13 cents per ton-mile.

With three trailing vehicles attached, whereby the load carried was increased to 12½ tons with no greater consumption of fuel, the total daily running costs aggregated $14.83, the increased expenses comprising the items for depreciation upon the augmented capital due to the inclusion of the third trailer and the depreciation upon the same. Covering 32 miles per day in five round trips, a total of 400 ton-miles was secured, and the daily costs divided by this represent 3.70 cents per ton-mile; while with the six journeys per day, representing a total of 38.4 miles, the lowest working cost was attained—3.08 cents per ton-mile. The firm anticipates that when the men become more experienced in the handling of the train, avoiding unnecessarily long delays in loading and unloading, thereby dispensing with much idle running of the engine, the gasoline consumption will be reduced; which in view of its constituting one of the heaviest items in the expenditure account, will tend toward lower running costs. At the same time, however, the fact that transport can be effected at about 3 cents per ton-mile is excellent testimony of the value and commercial practicability of the system, and with a 20-ton load, which the 75-horse-power motor is quite capable of hauling upon the same fuel consumption, the charges would be brought to a very low figure. In this present case, owing to the greater economy of the system combined with increased mileage per day possible with this mechanical traction as compared with horse traction, this Antwerp transport firm has abolished animal haulage and adopted the Renard system entirely.

RENARD TRAIN IN SERVICE AT ANTWERP CARRYING FREIGHT AT A COST OF 3.08 CENTS PER TON MILE.

CALCULATING PORTLAND CEMENT CLINKER.

The usual rule for calculating the clinker formed by burning a raw material is to add the percentages of silica, oxide of iron and alumina, lime and magnesia and to divide this sum into the percentage of each compound, multiplied by 100, for the percentage of that compound which will be present in the clinker. The results thus obtained for silica, for iron oxide and alumina will be too low and the lime much too high. This is because the ash of the fuel enters into the composition of the clinker, and also because the clinker contains constituents present in the raw materials not entirely volatilized in burning, viz., soda, potash, sulphur, trioxide, etc., carbon dioxide and water.

To calculate the composition of the clinker from the analysis of the raw material is therefore impossible, and we must assume certain corrections. First of these is for the coal ash entering into the clinker. Experiments show that in the rotary kiln about one-half of the ash enters the clinker. West Virginia gas slack coal averages about 10 per cent ash, composed of about 40 per cent silica and about 20 per cent each of iron oxide and alumina. If 90 pounds of coal are required to burn a barrel of cement, about 15 pounds (equivalent to 1.5 pounds of ash) are required per 100 pounds raw material burned. If half the ash enters the raw material, the silica is increased by $\frac{1}{2} \times 1.5 \times 0.40 = 0.30$ per cent, and the iron and alumina each $\frac{1}{2} \times 1.5 \times 0.20 = 0.15$ per cent.

Analyses of Lehigh Valley clinker, fresh from the kilns, show it to contain about 2 per cent of potash, soda, sulphur compounds, carbon dioxide and water combined. Clinker from other localities will probably not vary widely from this.

Assuming the above corrections the rule for calculating clinker from the mix analysis is as follows:

Add the percentages of silica, oxide of iron, alumina, lime and magnesia. To the sum add 2.75. Call the result the "clinker total."

To find percentage of silicate, add 0.30 to the percentage of silica in the raw material, multiply the sum by 100 and divide the "clinker total" as found above. The result will be the percentage of silica in the clinker.

To find percentage of iron oxide or alumina add 0.15 to the percentage of iron oxide or alumina in the material, multiply by 100 and divide by clinker total.

To find percentage of lime or magnesia, divide percentages of these by clinker total.—From The Chemical Engineer.

COAL MINE ACCIDENTS.

Accidents in the coal mines of the United States in 1907 resulted in death to 3,125 men and injury to 5,316 more—an increase of 1,033 in the number of deaths and 516 in the number of injuries over the record for 1906. This record marks the year, in all other respects the most prosperous, as one of the worst in the history of the coal-mining industry of the country. Even the above figures, however, fail to represent the full extent of the disasters, for any statistical statement that attempts to cover coal-mining accidents for the entire United States is necessarily somewhat incomplete. The U. S. Geological Survey, by which the figures for the country are published, does not collect the information directly, but obtains it through the courtesy of State or territory mine inspectors or other officials who compile data concerning accidents and their causes and effects. A number of the coal-producing States have no officials charged with these duties, and one or two of the State officials failed to reply to the inquiries sent out by the survey. In 1906 returns were received from twenty-one States and territories; in 1907 only eighteen reported. The reports received indicate a death rate per thousand employees of 3.31 in 1906 and 4.86 in 1907, and the number of tons mined for each life lost decreased from 194,950 to 145,471. The State which had the lowest death rate per thousand (0.95) in 1907 was Missouri, where 499,742 tons of coal were mined for each life lost. Michigan was second on the roll of honor as far as death rate per thousand employees was concerned, and Kentucky was second in the number of tons mined for each life lost. The death rate in Michigan was 1.76 per thousand; in Kentucky it was 1.89. Kentucky mined 336,035 tons of coal for each life lost; Michigan mined 290,837 tons. Arkansas reported a death rate of 1.97 in 1907, with 133,522 tons mined for each life lost, and Utah, with a death rate of 2.72, mined 324,601 tons for each life lost. West Virginia reported the largest death rate in 1907—12.35 per thousand—and the lowest production for each life lost—65,969 tons. New Mexico stood next to West Virginia, with a death rate of 11.45 and a production of 77,322 tons for each life lost, and Alabama was next, with a death rate of 7.2 per thousand and a production of 92,535 tons for each life lost.—Science.

THE THERMOGRAPH.

APPARATUS FOR PHOTOGRAPHICALLY RECORDING FLUCTUATIONS IN TEMPERATURE.

BY OUR BERLIN CORRESPONDENT.

THE thermograph is an apparatus recently constructed by C. P. Goerz for photographically recording any fluctuations in temperature undergone within a given interval of time by liquids or more consistent substances. The type represented in the accompanying figures was designed for ascertaining the behavior of such temperature oscillations as take place during the setting of cement. To this effect, a vessel is filled with the material to be tested, and a thermometer is inserted into the latter. The scale of this thermometer is lighted by a lamp located at a convenient distance, and the actual position of the mercury in the thermometer is projected and recorded on a photographic plate moved along by clockwork at a given speed.

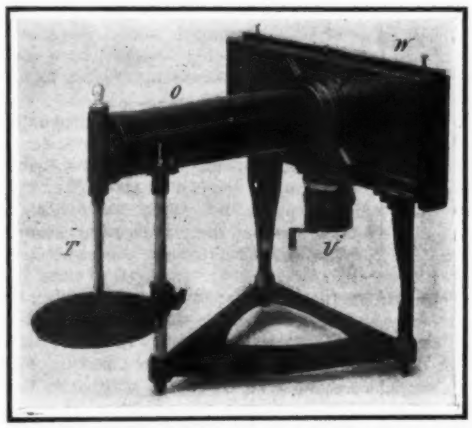
On developing the plate it is seen to be traversed by a number of parallel horizontal lines, due to the graduation of the thermometer. The maximum and minimum temperatures that have been obtaining during the setting process are read at a glance, whereas an ordinate pattern, placed on the negative or printed on the positive, is used for ascertaining the times. The thermometer is graduated in degrees Centigrade, any intermediary figures being readily estimated.

As indicated in one of the accompanying engravings, the thermometer is inserted in the socket *T*, the photographic lens within the tube *O*, the clockwork is mounted at *U*, and the slide carriage at *W*, actuated by the clockwork.

The thermometer socket is closed by a copper-plated steel sleeve, which can be withdrawn, and which in course of operation is kept filled with paraffin, mercury, or the like, in order to insure a satisfactory heat contact between the socket and the thermometer.

The clockwork comprises two small pinions, which are alternately thrown into gear with the rack of the slide carriage *W* by moving a ring to the left or right. When the stop visible at the front of the clockwork meshes with the right-hand spring, the clockwork will move the slide carriage from left to right through 144 millimeters (5.7 inches) in twelve hours, and when it meshes with the left-hand spring, through the same distance in twenty-four hours.

The source of light should be placed at a distance of about 1 meter (39 inches) and at the level of the objective tube in front of the apparatus, so as to be situated in the line of vision above the knobs shown in the figure. The material to be tested should be imbedded in sawdust, and placed in a felt vessel on the disk or table of the apparatus. After then filling the removable sleeve of the socket with the heat conducting medium, the thermometer should be inserted, and the slide carriage started at the proper moment.



FRONT VIEW, SHOWING THE TABLE AND THE THERMOMETER HOLDER.


REAR VIEW, SHOWING SLIDING PLATE CARRIER.

THE STRUCTURE OF THE ATOM.*

By SIR OLIVER LODGE, D.Sc., F.R.S.

THE atom of matter, sometimes called the ultimate atom, has been the object of frequent speculation, and likewise the subject of much scientific skepticism. In my youth, chemists usually guarded themselves, when they used the term atom, from being supposed necessarily to imply that such things really existed. And when they depicted a possible arrangement of atoms in a molecule, by means of a graphic formula, it was always in an apologetic spirit, as if such representation conveniently expressed some part of the facts, without necessarily representing anything really existent in nature. This skepticism was in some sort wise, no doubt, but in my judgment was carried too far. If a graphic formula conveniently represented some of the facts, it must be because it genuinely corresponded to something real and true. That it was a complete or adequate representation no one could imagine; but that it was worthy of being favorably regarded for whatever was true in it, without being subject to constant detrimental criticism, I fully believe. How could the formulæ correspond to reality when they were only diagrams drawn upon flat paper? They certainly could not; but these drawings might have been regarded as plane projections of a grouping in space, and an effort might have been made to conceive the real groupings which could be thus imperfectly represented. Had there been faith in the reality and genuine character of some such grouping, the attempt to realize what it might be really like would have been made far sooner than it was, for the idea of such an attempt is an obvious one—the merit of those who have now at last properly worked at it (Van't Hoff and others) consists in the way they have elaborated the details and applied them in a consistent manner to explain the properties of a great variety of compounds and their allotropic forms.

So also the bare idea of "survival of the fittest" was an obvious one—the narrative of every shipwreck and most fires and colliery disasters contains examples of it; the idea and its tendency could be, and were conceived clearly by a naturalist in the space of some two hours. The major merit is held to belong to the careful elaboration of details, and the patient scrutiny of theory in the light of a vast number of facts, over a period of thirty years. But this work would not have been undertaken if there had been fundamental skepticism as to the existence of species. The existence and problem of species was the stimulating factor.

The old idea of species has been modified, however—there is nothing absolute about it now, as there was when each was thought to be a special creation. And similarly the idea of an atom has changed—there is nothing ultimate about it now, as there was when it was thought that the atom of each element was a special creation. The notion of evolution has invaded both departments of knowledge; and atoms are seen, in some cases at least, to merge into one another, and to be resolvable into other and still simpler units. But, in spite of all that, the atom always was and shall remain a useful conception; and the arrangement of atoms in a molecule, as now depicted by chemists, in all probability corresponds with something quite genuinely real. I see that Prof. Larmor suggested the other day, in Manchester, that such arrangement may directly determine crystalline form; and that a study of crystals may be one of the clues to real molecular structure. This notion should be pressed and examined for all it is worth. The fear lest any hypothesis may become too fixed and binding is wholesome, but it goes too far when it exerts a deleterious influence on thought and discovery. If we could dissect out and examine a molecule, it is highly unlikely that we should find anything static—a frozen, rigid assemblage of atoms grouped in the way we depict; but it seems to me extremely likely that the actuality, when we find it, will kinetically resemble and correspond to so many features in our present static representation that we shall have to admit such representation as a genuine step in the direction of truth. And a step is always a thing to be taken, not to be criticised and boggled over. Each step upward, if properly taken and utilized, makes the next step on more accessible and easier. And if it happens to be a false step, too weak to bear any weight, we shall ascertain the fact most quickly by frankly treading or even jumping upon it.

At present we are dealing, however, not so much with the chemical structure of the molecule as with the physical structure of the atom.

Attempts to visualize the actual processes occurring in nature are wholly legitimate, and if persisted in long enough are nearly always fruitful. It is the glory of science to take what is superficially complex and empirical and confused, and to convert it, by long-continued critical and imaginative inspection, into something orderly and systematic and intelligible; probing into the hidden nature of the working, and disentangling from the obvious or phenomenal, that which, though unperceived by the senses, is really far more accessible to mental grasp. Every such generalization is a step in the direction of unification, and leads us on toward that ultimate unity, and in a sense simplicity, which is the object of all philosophy and of a great part of science. For the multifarious appearances around us are probably all going to be resolved into the movements and groupings of an immense number of precisely similar elements. Our business is to ascertain what those elements are, how in each case they are grouped, by what means they are connected, and how they act upon each other. And then we may further inquire how far they are influenced by some other aspects of the universe, beyond the material range, outside the familiar categories of matter and ether and electro-magnetism and mechanics.

* Abstract of a lecture delivered before the Society of Chemical Industry.

THE SPLASH OF A ROUGH SPHERE.

PROF. A. M. WORTHINGTON, F.R.S., has studied "A Remarkable Feature in the Splash of a Rough Sphere." He explains that, experimenting with a rough sphere (a roughened marble simply, e. g.), instead of a smooth ball previously used, he has observed quite different results, when the height of fall exceeded a certain critical value. With spheres 1.5 centimeters in diameter this critical height was reached below 70 centimeters and above 140 centimeters, and a further increase to 680 centimeters (22½ feet) made no material difference. Below that critical height the splash was characterized by an upward jet thrown high into the air, forming above the water-surface a cylinder, which gradually closed above to a cup, partly dissolving into splashes as it flattened. The sphere itself drew a sack of air after it, which contracted in its middle portion and then dissolved. When the critical height was passed, this sack was pierced by a central downward jet of the liquid (water petroleum) directed from above along the axis of the air-sack. The instantaneous photographs exhibited (in which the ball itself could hardly be distinguished at the bottom of a dark sack) showed that this downward jet was due to a permanent closing, at an early stage, of the mouth of the air column by a film of the liquid, and to the subsequent reduction in the pressure of the confined air through the piston-like action of the sphere, when its momentum was large enough. With great height of fall the jet started some distance below the surface of the liquid.

SOLAR ECLIPSES AND ANCIENT HISTORY.*

AN INVESTIGATION OF SOME HISTORICAL ECLIPSES.

BY SAMUEL JENNINGS.

There are few natural phenomena so impressive to the spectator as a total eclipse of the sun. Even if he is looking for it, watching its development and already, to some extent, prepared for what he is about to see, the effect produced upon him by the few minutes of totality is most awe-inspiring.

But in people who do not know what is happening the most dread apprehension is aroused, and, as the climax approaches, they are filled with superstitious terror, the memory of which cannot fade away. It will be handed down from generation to generation, particularly when associated with some historical event which took place about the same time. Need we wonder, then, that events which have created so deep an impression have been recorded in ancient writings?

It might be supposed that such records would furnish for all time a ready and reliable means of determining with certainty the precise dates of such historical occurrences as have been thus signally marked.

Unfortunately, until within the last two or three years, such verification of identity of the ancient total solar eclipses has not been found possible, and at least one distinguished astronomer has come to the conclusion that all these eclipses must be put on one side as untrustworthy, or as too vague to be utilized.

Could these records of ancient eclipses be accurately identified they would be of inestimable value in enabling astronomers to correct and extend our knowledge of the apparent motions of the sun and moon, at periods far apart from each other, the exact position of each of these bodies would be known, and data furnished upon which to base the necessary computations.

Many efforts have been made in the past to bring these various eclipses into harmony with each other, but without success. It has not, therefore, been felt that the information available was sufficient to warrant reliance upon these ancient dates in modern astronomical computations.

These difficulties have now, however, been overcome by the work of Mr. P. H. Cowell, F.R.S., Chief Assistant at the Royal Observatory, Greenwich. All these ancient eclipses now fall into their several places, and their respective zones of totality can be marked upon the map.

How Mr. Cowell reached these interesting and important determinations must now be explained. The results pass beyond the province of astronomical science, and penetrate into the domain of history and suggest reasonable solutions of many a difficulty which has hitherto perplexed students of the classics; they penetrate even into the realm of Biblical literature.

More than two centuries ago, in 1693, Halley, afterward second astronomer royal, showed that the month was very slowly changing in length. The amount of this change was first measured correctly by Prof. Simon Newcomb, the great American astronomer, who, in 1878, discussed the times of nineteen eclipses of the moon recorded by Claudius Ptolemy, the astronomer of Alexandria, as having taken place between B.C. 721, and A.D. 136. But it never occurred to Prof. Newcomb to take into consideration the possibility that there might be a change in the length of the year, and when he turned his attention to the supposed records of ancient solar eclipses, they did not accord with his calculations. He therefore rejected them all as untrustworthy.

It must be admitted that there is considerable margin of doubt as to the interpretation to be put upon any one of these ancient references to eclipses when taken by itself apart from others. Several of the records in question were not written until long after the event; the place where the eclipse occurred is not always definitely indicated, and, in one or two cases, the expressions used might accord with some merely atmospheric obscuration. But great reluctance must be felt in discarding the whole of such evidence.

Mr. Cowell's inquiry gives cause for concluding that the want of accord between these ancient records and Prof. Newcomb's computations can be explained by one single hypothesis not in any way beyond the bounds of possibility. This hypothesis is that the ratio of the length of the day to the length of the year is very slowly changing, probably due to tidal friction; though the tables at present in use assume that there is no such change.

Mr. Cowell devoted the years 1903-1904 to a discussion of the modern observations of the moon, those made at Greenwich in the last hundred and fifty years. He then took up the following five ancient eclipses of the sun, viz.:

Nineveh	B.C. 763
Archilochus at Thasos	648
Thucydides at Athens	431
Agathocles near Syracuse	310
Tertullian at Utica	A.D. 197

and found them self-consistent. This consistency is the essence of the proof, for individually, as already pointed out, the records are often doubtful. Another point in favor of their acceptance is that the rate of change in the length of the month deduced from these eclipses agrees with Newcomb's result, derived in 1878 from the eclipses of the moon.

The record of a sixth eclipse, the most ancient yet available to us, was then discovered by Dr. L. W. King on one of the cuneiform tablets in the British Museum. It would appear to refer to an eclipse of the sun observed at Babylon, B.C. 1063. Here also, as with the five other records, there is some uncertainty in the interpretation, but this eclipse also exactly fits in with the other five.

The question therefore stands thus: The astronomical tables at present in use do not account for these six eclipses as they are recorded. This may arise from one of two reasons, either—"an historian, poet, or chronicler recorded an eclipse in which the limit of totality was an unknown number of miles distant from the point of record, or the astronomical tables at present in use require some correction."* But if the descriptions of these six eclipses are thus inaccurate, then, seeing how widely separated they are in time and place, it seems beyond all probability that one single hypothesis as to the necessary alteration of the table would produce harmony between them all.

It is not sufficiently realized how rare an occurrence a total eclipse is at any particular spot. On the average such an event occurs only once in three hundred years for any given place. The last eclipse visible in England was that of 1724, the next to be seen in this country will be that of 1927, an interval of more than two hundred years, not for a single city, but for the country as a whole. The last visible in London was that of 1715, the next previous one visible in London was that of 873. It does not appear that another will be visible here for at least some six hundred years to come.

A little later on, Mr. Cowell examined three mediæval eclipses, namely, A.D. 1030, 1239, and 1241, besides two further ancient eclipses which he had previously left on one side. The records in these two instances had received identifications which were manifestly wrong, and they had been put aside by Prof. Newcomb as either not being historical at all, or as referring to some phenomenon other than an eclipse. But both these, as well as the three mediæval eclipses, fitted in completely with Mr. Cowell's computations.

The record of an eclipse of the moon stands on quite a different footing from that of an eclipse of the sun. There is no wide difference as to impressiveness between a total and a partial lunar eclipse. A total eclipse of the sun is, on the other hand, a thing apart, and widely different in the sensations to which it gives rise from a partial eclipse, however little the latter may fall short of complete totality. Further, in a lunar eclipse the moon is really darkened, hence the eclipse, whatever its magnitude, is the same over the whole of the hemisphere of the earth turned toward it at the time. A total eclipse of the sun is total only over a very narrow belt of the earth's surface. From the nature of the case, therefore, eclipses of the moon afford much less valuable evidence in lunar theory than eclipses of the sun, and the whole series of nineteen eclipses given by Ptolemy are not together worth more than a single solar eclipse. Mr. Cowell has, however, discussed these nineteen eclipses of the moon, taking into consideration their recorded magnitude, a detail with which Prof. Newcomb had not dealt, and found that they were in accord with his hypothesis of a very minute change in the relative lengths of the day and year.

The astronomical evidence therefore in support of this hypothesis rests upon seven solar eclipses before the Christian era, four solar eclipses since, and is consistent with the general testimony of nineteen lunar eclipses.

But the last two solar eclipses named are of especial interest from more than one point of view. They are those which are commonly known as "the eclipse of Larissa" and "the eclipse of Thales." Both these eclipses have been in dispute from the very earliest times, both have been wrongly identified, and the errors have been followed by the best historical authorities even down to the present day, with results which have considerably dislocated the history of that period.

Our knowledge of the first of these eclipses—that of Larissa—is derived from Xenophon, who, in his account of the Retreat of the Ten Thousand, writes:

"After this defeat the Persians retired and the Greeks, marching the rest of the day without disturbance, came to the River Tigris, where stood a large uninhabited city called Larissa, anciently inhabited by the Medes, the walls of which were 25 feet in breadth, 100 feet in height, and 2 parasangs in circuit, all built of brick except the plinth which was of stone and 20 feet high. This city, when besieged by the King of Persia, at the time the Persians were wresting the empire from the Medes, he could not make himself master of by any means, when it happened that the sun, obscured by a cloud, disappeared, and the darkness continued till the inhabitants being seized with consternation, the town was taken." (Anabasis, Book III, chap. iv.)

Larissa has been identified as Calah, eighteen miles from Nineveh. The late astronomer Sir G. B. Airy, writing in 1856, identified the eclipse of Larissa with that of May 19, 557 B.C. and showed that according to Hansen's Tables of the Moon, the narrow zone of totality passed nearly centrally over Larissa, and that there was no other eclipse within a period of forty years which could have been total at Larissa. But the growth of our knowledge in two directions has rendered Airy's identification impossible. The tables he used are inconsistent with modern observations of the moon, and the zone of totality of this eclipse must have lain hundreds of miles to the south of Larissa.

Mr. Nevill, director of the Natal Observatory, has further pointed out that the great progress which has been made in our knowledge of Assyrian history and chronology since the time when Airy wrote has enabled the actual dates of many events in Assyrian history to be determined with certainty, and that "Nineveh, Calah, and other great cities of Assyria disappeared from history before B.C. 600, and the very state of their ruins at the present time shows that the destruction was sudden and once for all. Every inhabitant perished or was transported in slavery to some distant spot, and the cities were never allowed to be reinhabited. The capture of Larissa to which the tradition refers must be the capture of the Assyrian Calah by the Medes and Babylonians prior to B.C. 600, and could not refer to the capture by the Persians of a town of whose existence there is no record, and of whose remains there is no sign among the existing ruins of Calah. As before remarked, the very state of the ruins shows that Calah was an Assyrian city when destroyed, prior to B.C. 600, and that its destruction was final."*

With the tables of the moon, as corrected by Mr. Cowell, one eclipse, and only one, becomes total at Calah, namely, that of B.C. 603, May 18. This date fits in remarkably with the chronology of the fall of Nineveh. The great siege began B.C. 609. Nineveh fell three years later. In 605, the Chaldeans defeated the Egyptians at Carchemish, to which city the latter would scarcely have ventured to advance if not only Nineveh, but also its dependent cities had already fallen. Then, as Mr. Cowell points out, the Chaldeans are lost sight of for three years, and in B.C. 601 or 600, they invaded Judea.† "The capture of Larissa exactly fits into this gap of three years in the current Assyriological knowledge."

It is, of course, conceivable that Xenophon's "great cloud" may not refer to a total eclipse of the sun at all, but when we consider how deep an impression such an event as a total eclipse of the sun must always have produced, especially upon the Assyrians, to whom the sun represented their ruling deity, Asshur, there can be no real doubt about the identification. For, if the "great cloud" do not refer to the eclipse, then we are obliged to assume that the eclipse, which certainly did take place about the very time of the siege, passed without chronicle, while some unexplained darkening of the sun, which, if merely meteorologi-

* Journal of the Royal Astronomical Society of Canada.

* Prof. Simon Newcomb, Monthly Notices of the Royal Astronomical Society, vol. lxvi., page 34.

* E. Nevill, Monthly Notices of the Royal Astronomical Society, vol. lxvi., page 409.

† P. H. Cowell, The Observatory, March, 1907, page 138.

cal, would have nothing of portentousness, must have attracted attention which the eclipse failed to secure.

Referring again to the quotation from Xenophon, it will be seen that the historian had clearly fallen into error in placing the eclipse of Larissa as occurring "when the Persians were wresting the empire from the Medes." The date usually assigned to this revolt was about B.C. 559. Astronomy tells us that a total solar eclipse did take place on May 19, B.C. 557, and that it was visible as a very large partial eclipse in this region. It cannot, therefore, be doubted that Xenophon accepted the traditions of two separate eclipses, those of B.C. 603 and B.C. 557, under the misconception that they were one and the same. Similar vague traditions had misled Herodotus into serious error as to the date of the Eclipse of Thales, which took place on May 28, B.C. 585. His record concerning this eclipse is as follows:

"War lasted between the Lydians and the Medes for five years: during this period the Medes often defeated the Lydians and often the Lydians defeated the Medes; and during this time they had a kind of nocturnal engagement. In the sixth year when they were carrying on the war with nearly equal success, on occasion of an engagement, it happened that in the heat of battle, day was suddenly turned into night. This change of the day, Thales, the Milesian, had foretold to the Ionians, fixing beforehand this year as the very period in which the change actually took place.

"The Lydians and Medes seeing night succeeding in the place of day, desisted from fighting, and both showed a great anxiety to make peace." (Herod., Book I., chap. lxxiv.)

We then read that the matter in dispute was referred to arbitration: "Syennesis the Cilician and Labynetus (Nebuchadnezzar) the Babylonian were the mediators of their reconciliation, these were they who hastened the treaty between them, and made a matrimonial connection, for they persuaded Alyattes to give his daughter Aryennis in marriage to Astyages, son of Cyaxares."

Further on in the same Book I., chap. ciii., alluding to Cyaxares, King of Media, Herodotus writes: "It was he that fought with the Lydians when the day was turned into night as they were fighting; and who subjected the whole of Asia above the River Halys. He assembled the forces of all his subjects and marched against Nineveh to avenge his father and destroy that city."

This passage would convey the impression that the fall of Nineveh took place *after* the war with Lydia, and it seems certain that Herodotus believed it was so, and he would therefore associate the eclipse of B.C. 610 with that said to have been foretold by Thales. Modern chronologists, following Herodotus, have adopted the same view. Woodward and Cates, Fisher, Baxter, the Students' Bible and others adopt the year B.C. 610 as that in which the Lydian war ended; while Hales, Clinton, Blair (last edition, 1904), give us the later eclipse—B.C. 603. Herodotus certainly fixed upon one or the other of these two eclipses as the eclipse of Thales. If he adopted the earlier, that of 610, he was twenty-five years out of his reckoning, and if that of 603, he would be eighteen years wrong.

This mistake was not merely an error in chronology; it was more than that. Because he built up his history upon that supposition, he found it necessary to account for twenty-five imaginary years between the accession of Astyages and the fall of Babylon in B.C. 536; therefore he represented Astyages as a much older man than he really was. The importance of the disclosure of this mistake will be seen later on.

The eclipse of Thales, as has been shown, was originally identified with that of September 28, B.C. 610, but the path of the shadow in that year must have been too far north. Further, the war must have happened after the destruction of the Assyrian empire by the Medes and the Babylonians, and so have been later than B.C. 600. The eclipse of May 28, 585 B.C., on the other hand, passed through Asia Minor, and the sun set, according to Mr. Crowell's computation, totally eclipsed about east longitude 29.

This is exactly the phenomenon which appears to be indicated by the words of Herodotus in his reference to the "kind of nocturnal engagement" and that the "day was suddenly turned into night." We have no means of ascertaining the precise site of the battlefield.

It must be clearly borne in mind that there is no uncertainty as to the dates at which total eclipses of the sun have occurred, nor even any doubt as to the general regions of the earth crossed by the shadow. The only uncertainty has been as to the exact position of the zones of totality.

There have been only four eclipses which could possibly have taken place within the period covering the historical events referred to in the quotations given above from Herodotus and Xenophon, and visible in the localities concerned, namely:

September 30	B.C. 610
May 18	B.C. 603
May 28	B.C. 585
May 19	B.C. 557

The tables of the moon at present in use would give no one of the four as total at Larissa. It would be possible to suggest alterations in those tables which would make the eclipse of B.C. 557 total there, but if the same alteration were tried in the case of other eclipses, as, for instance, in the eclipse of Thucydides, at Athens, in the first year of the Peloponnesian war, it would be seen to utterly fail to satisfy the evidence, while we have now proof from Assyrian chronology that Larissa must have fallen before 600 B.C. Mr. Cowell's computations, however, at one and the same time, place the eclipse of 603 B.C. as total at Larissa, and satisfy the other ancient eclipses accessible to us. And the case is exactly analogous with the eclipse of Thales. It cannot have been the eclipse of 610, both from astronomical reasons, the path of the shadow lying too far to the north—and from historical, for it must have occurred later than the destruction of the Assyrian empire.

Both these eclipses, which, but a little while ago, were regarded as being outside any satisfactory identification, now fall into their proper places; that of Larissa in 603, and that of Thales in 585.

We gather from Herodotus that his information reached him through oral tradition, handed down through different channels. He selected that which appeared to him most likely to be correct. The occurrence of a total eclipse of the sun would be sure to leave behind an indelible mark upon the memory. But, while the *fact* would remain clear, the period when it took place, as time passed, would tend to become more and more vague. It would appear to become more remote.

Herodotus was evidently unacquainted with the ancient observations of eclipses by the Chaldeans, who had discovered that solar eclipses recurred after intervals of eighteen solar years. This period they called by the name of "Saros." Had the historian known this, it would not have been so wonderful to him that Thales, who had that knowledge, should have predicted an eclipse, and the eighteen years period would have at once indicated the eclipse which Thales foretold from his observations of the eclipse of 603, eighteen years after which came the eclipse of B.C. 585. Some few Greeks and modern writers have in this way determined the correct date of the eclipse of Thales, but, as we have seen, the weight of authority has followed the mistake of Herodotus.

So far, it will not be disputed that the determination of the eclipse of B.C. 585 marks with certainty the date of the accession and marriage of Astyages, and hence disposes once for all of the only serious difficulty in the way of the identification of Astyages with "Darius the Median" who, according to Daniel, received the kingdom of the Chaldeans "being about three score and two years old." (Dan., v., 31).

This is no new suggestion. Niebuhr, Westcott, and Vaux held this opinion, but admit a difficulty owing to the prevailing belief that Astyages must have been a much older man, even if he had been alive when Babylon fell in B.C. 536.

If, then, Astyages were sixty-two years of age in B.C. 536, he must have been born in B.C. 599-8, and would have been about fourteen years old at his accession and marriage, not an unusually early age in Eastern countries.

This forces another conclusion, viz., that Astyages could not have had a marriageable daughter (Mandane), said to have been the mother of Cyrus. Xenophon tells us that Cyrus was about fifteen or sixteen years of age when he hurled back the invasion of Media by Evil-Merodach in B.C. 559. (Cyro., chap. iv., p. 16). Cyrus was therefore born about B.C. 576-5, when Astyages was twenty-three years old. So that it is clear that, whatever the relationship between them, Cyrus could not have been the *grandson* of Astyages.

We arrive, then, at three tolerably certain deductions from the astronomical locations of these four eclipses: 1st, that Astyages was not an elderly man at his accession and marriage; 2d, that Cyrus was not his grandson; and 3d, that the question of his age is no longer the supposed insurmountable bar to his identification with Darius the Median.

It is well recognized that there are indications of a King Darius who had reigned in Persia before Darius Hystaspes, and it becomes more than probable that many references to "Darius," heretofore supposed to have been to the latter monarch, ought now to be understood as pertaining to the former—Astyages.

In Daniel, ix., 1, the father of Darius the Mede is stated to have been Ahasuerus. According to Scaliger and others, the names Cyaxares and Ahasuerus are identical, the one being a Greek form of the other, and no one disputes that Astyages was the son of Cyaxares I. the Medo-Persian king, who, in alliance with the Chaldeans, destroyed the Assyrian empire in B.C. 606, which event is alluded to in Tobit, xiv. 15. "But before he [Tobias] died, he heard of the destruction of Nineveh, which was taken by Nebuchadnessor and Assuerus." Moreover, Josephus says that Darius was known to the Greeks by another name. It is very unlikely that Herodotus ever heard the name Darius from Persians, who, according to Spiegel (Eran., p. 88) "did not remember the names of their king, even the great Darius Hystaspes came back to them through the Greek traditions concerning Alexander."

Daniel may, therefore, be understood to tell us that Darius the Mede was the son of Cyaxares, in which case his identity is fully established.

One further point may be worthy of mention. In an inscription found by Sir Fenwick Williams of Kars, in 1850, upon the base of one of the pillars of the great temple at Susa (Shushan) is a statement of Artaxerxes (Memnon) tracing his descent in the usual grandiloquent language, through Xerxes to Darius Hystaspes. It concludes thus: "Darius, my ancestor, anciently built this temple, and afterward it was repaired by Artaxerxes, my grandfather." The word "anciently" would appear to denote a Darius *before* the time of Hystaspes, probably Darius the Mede. He had already mentioned Hystaspes, and had he meant his son, he would scarcely have used the word "anciently."

Xenophon introduces a king of Medo-Persia, whom he names Cyaxares II., son and successor to Astyages, of whom no trace can be found in any other writer. On the other hand, Herodotus distinctly states that Astyages was the last king of the Medes, and that he was succeeded by Cyrus. His statement receives direct confirmation in the apocryphal fragment entitled "Bel and the Dragon," which commences thus: "And King Astyages was gathered to his fathers, and Cyrus of Persia received his kingdom and Daniel conversed with the king and was honored before all his friends. And the Babylonians had an idol," etc. This agrees with Daniel, vi. 1-3, where Astyages is called Darius, and the period is clearly after the fall of Babylon, and may be accepted as evidence that he was reigning in Babylon (*circa* B.C. 535-4). We also have evidence that the same Darius was reigning in Ecbatana only a year or two previously. This is afforded in I Esdras iii. and iv., where is a story concerning Darius and Zerubbabel, also narrated by Josephus (Antiq., Book XI., chap. iii) under the erroneous impression that the Darius here referred to was Darius Hystaspes, a chronological mistake arising from the original error of Herodotus in antedating the accession of Astyages by twenty-five years, as proved by the now indisputable date of the eclipse of Thales. Josephus, who was unaware of the identity of Astyages with Darius the Mede, offers a very lame explanation of a supposed visit of Zerubbabel to Darius Hystaspes fifteen years after the first return of the Jews to Jerusalem. He could not then have been the "young man" as he is described in I Esdras. In the new light, however, this narrative finds its true historical place in B.C. 536, after the capture of Babylon by Cyrus, whose decree in favor of the Jews had been sent to Darius (Astyages) for confirmation, but it was strongly opposed. (Daniel, x. 13). It is suggested that this narrative of "the three young men" relates the circumstances which led to the ratification of the decree and the appointment of Zerubbabel to carry it out.

It will be remembered that Astyages and Cyrus were joint kings; their reign over the Babylonian empire began simultaneously, therefore "the first year of Cyrus" (Ezra, i.) was also "the first year of Darius" (the Mede, Daniel, ix. 1) Astyages having died in the meantime, "the third year of Cyrus" (Daniel, x., 1) indicating that Cyrus was then sole king.

This may possibly explain why, when search was made for the decree of Cyrus by order of Darius Hystaspes fifteen years later, as recorded in Ezra, vi., 1-2, it was not found in the archives of Babylon but in the palace of Ecbatana in Media.

Still more surprising results follow the recognition of King Ahasuerus of the Book of Esther in this same Astyages of Medo-Persia. No more than the briefest outline of these results can be afforded here.

Having the precise date of the accession of Astyages, it now becomes possible to determine what took place in the third, the seventh, and the twelfth years of his reign, when certain events recorded in the Book of Esther occurred.

Reading these events into the narratives of Herodotus and Xenophon, which have been considered quite irreconcilable, a reason is at once shown why so many different and contradictory traditions were handed down to the historians. The political situation of the period comes to light, the mystery of the birth of Cyrus seems cleared up, the palace intrigues, the maneuvers of two hostile parties leading up to the revolt against Astyages, the cause of the bitter hatred of the Medes against Cyrus, the reason why Crœsus, King of Lydia, invaded Cappadocia, all these things become plain when read in the light of the record of the Book of Esther.

Starting with the accession of Astyages and the treaty of the River Halys under which he is married to the daughter of Alyattes, King of Lydia, in B.C. 585, his third year would be B.C. 582, when his queen was disgraced and divorced. His seventh year would be B.C. 578-7, when he raised the Jewess Esther to

be queen in place of Vashti, and the plot to destroy the Jews which took place in his twelfth year, would be in B.C. 573-2.

When it is remembered that the divorced queen was the daughter of the then king of Lydia, and the sister of Crœsus, and that attempts were made to effect her restoration which nearly succeeded (Esther, ii. 1) but were strenuously opposed by the servants of the king, we see two political parties, the one, doubtless supported, and perhaps instigated, by the Lydian Court, incensed by the outrage against the queen which was a practical breach of the treaty, the other, as firmly determined to avert what they deemed would have been a national humiliation. They were respectively the queen's party and the king's party, and the speedy enthronement of a new queen was intended to destroy the hopes of the queen's supporters. Esther became queen in B.C. 577. We have already seen that Cyrus was born in B.C. 576, the year following the marriage of Astyages to Esther, and Herodotus tells us that Cyrus was born in the palace of Astyages. There is no direct statement that Cyrus was the son of Astyages, but the inference, both from the place of his birth and the date thus indicated, suggestively point to the probability that his mother was Queen Esther. Mandane, said to have been the daughter of Astyages, could not have been the mother of Cyrus, but she might possibly have been, not his daughter, but his sister, married to Cambyses, the Persian, and the plot against the life of the infant, narrated by Herodotus, a purposely garbled version of what actually occurred, viz., that his life was in real danger from a palace intrigue, from which he was saved by Harpagus, who conveyed the child secretly to the care of Mandane in Persia, out of reach of his enemies, and Cyrus became their *adopted* son, this bringing Xenophon's story into line and accounting for the anxiety of Astyages, when Cyrus was brought home to Media when he was in his twelfth year, lest any harm should befall him. The king's determination that Cyrus should succeed him is shown by the promptness with which he was created associate military king, which was the immediate cause of the open revolt of the Medes against Cyrus, who was in command of the Persian army.

Ctesias, reflecting the bitterness of the defeated Medes, attributes their downfall to the treachery of Cyrus and Harpagus; he accuses the former of having revolted against Astyages and basely attacking him. Had this been so, how came it to pass that the fighting began in Persia and not in Media? The latter, Harpagus, had been appointed by Astyages to command the Median troops. Herodotus expresses his amazement that such an appointment was made, "as though the gods had deprived Astyages of reason." But, in the new light on the political situation, it becomes clear that, while the queen's party supporting Vashti, with probable assurances of assistance from Lydia, had gathered strength in Media, Astyages was still determined to support Cyrus, and hence gave the command of the Median forces to Harpagus, whom he knew to be the friend of Cyrus, and sent him to lead them against the Persians, with the result recorded by history. We can perfectly understand why the Medes cried "treachery," the usual cry of a defeated party. There was evidently no hostility against the king, whose reign was, as we have seen, unbroken by this so-called revolt. Astyages continued to reign at home, while Cyrus pursued his career of military success abroad, first defeating the Lydian attack by Crœsus, and adding province after province and kingdom after kingdom to the Medo-Persian Empire, which, under the administrative genius of Astyages (Darius) became organized into one hundred and twenty-seven provinces. Astyages died in B.C. 535-4, and Cyrus then became sole king.

Here we have a new, and apparently at first sight a fanciful history of the reign of Astyages, but on closer examination, it will be found to afford a reasonable explanation to account for most of the difficulties admitted to attend every attempt to reconcile the conflicting records of Herodotus, Xenophon, and others. Both these historians based their narratives upon century-old traditions, the one through channels hostile to Cyrus, the other regarding him as a veritable hero. We reject the idea that any of these ancient records are pure romance. They are founded upon fact, but distorted to suit the political bias of the narrators.

The uncertainty which from the very first has attended the identification of the Eclipse of Thales being now absolutely cleared up by the recent astronomical researches of Mr. Cowell, we are furnished with the certain date from which to reckon the events of the reign of Astyages, and are enabled to bring the successive incidents recorded in the Book of Esther into their proper historical places. These, in their turn, throw a new light upon the narratives of the ancient historians, the full importance of which it is scarcely possible to apprehend at present.

It is no small matter that the unconscious mistakes passed along over a period of two thousand years should now be rectified. Neither does it in the slightest degree reflect discredit upon the long succession of learned authorities who have dealt with this subject, because the information now at our disposal was not and could not have been theirs.

ENGINEERING NOTES.

An automobile street sweeper has recently been put in operation in Paris, France. It is actuated by a 16-horse-power motor and travels from 4 to 6 miles per hour. It is provided with a water tank and pump, by means of which water in the form of a nebula or fine spray is directed on the pavement in advance of the roller broom for the purpose of agglomerating the particles of dust. The amount of water used is very small, being only about 1 gallon for 1,200 square feet of pavement swept.

The Pan-American railway project, says the Engineering Record, was pushed forward another link on July 1, when the Tehuantepec Railway's southern branch was completed to the boundary between Mexico and Guatemala. On the Guatemala side of the line there is an interoceanic railway recently put in service after a good many years of intermittent construction, and President Cabrera announced a few weeks ago that construction would shortly be started near San José, on this road, of a branch running north to a connection with the Mexican system.

A process which makes possible the substitution of steel for malleable iron in many articles of light hardware has been invented by Mr. L. S. Lachman, and is described in the Engineering and Mining Journal. The method is founded primarily upon the idea that as two pieces of metal of unequal section do not unite readily to form a good weld, two points, or a point and a ridge, must be raised on the pieces to be united. These raised contacts are forced together under hydraulic pressure and, forming the link of lowest conductivity in an electric circuit, are heated by the current to a temperature at or near fusion; the two projections are thus quickly united and form a bond or rivet which is even stronger than an ordinary rivet, because it is in one piece with the body of the metal.

A new refrigerator car has been successfully tested during the past month, the invention of a commission merchant of Minneapolis, Minn. In this car the ice-box is situated in the center of the car and overhead, with false ceiling and ends to promote circulation of the air within the car. The ordinary car has the ice bunkers at each end, and as a result warm air gets toward the center and near the top of the car, and it is said that perishable goods cannot be loaded to much more than one-half or two-thirds of the capacity of the car. With the overhead scheme it is claimed that very much more goods can be loaded into the car, and they are kept at more uniformly low temperature with less consumption of ice. Another inventor has secured a patent for movable partitions for ice bunkers, so that these may be situated in the center of the car or at either end, as desired, or taken out altogether.

In a very thoughtful article by Prof. William Z. Ripley on "The Theory of Railroad Rates," in the Railroad Age Gazette, this statement occurs: "The average weight of a locomotive at the close of the civil war was approximately 90,000 pounds. This has increased in somewhat the following proportions: To 1881, 102,000 pounds; to 1893, 135,000; to 1895, 148,000; to 1898, 230,000; rising in 1900 to 250,000." The increase in the average weight of locomotives between 1895 and 1898, as stated above, seems to Mr. R. V. Taylor, general manager of the Mobile & Ohio Railway, to be incredible, and not less so is the statement that the average weight of locomotives in 1900 was 250,000, or 125 tons. In a letter addressed to our contemporary he asks: "Cannot the real explanation of this seeming improbability be found in the fact that Prof. Ripley used the weight of the locomotives up to and including 1895, and the weight of the locomotives and tenders for the subsequent period named?"

A series of paint tests which promise to furnish valuable data have been undertaken in several parts of the United States by the Paint Manufacturers' Association. The first of these tests was begun nearly two years ago by the North Dakota Agricultural College at Fargo, at the request of the Association, which contributed a sum of money for the purpose. The formulæ representing the paint manufacturers' products were selected by Prof. Ladd in conference with Mr. G. B. Heckel, and Prof. Ladd invited white lead manufacturers and others to participate, which they did. The formulæ furnished for the paint manufacturers numbered sixteen, representing all the popular and successful types of prepared paints on the market, ranging from a base of straight lead and zinc in varying proportions to a combination of zinc and barium sulphate. In these formulæ all the reinforcing or inert pigments were represented, including silica, calcium carbonate, calcium sulphate, magnesium silicate, etc., the object being to provide formulæ which, without duplicating existing paints, would each stand as typical of its class.

TRADE NOTES AND FORMULÆ.

Cellulose Solvent.—1 part chloride of zinc dissolved in 2 parts of glacial vinegar, of 1.44 specific gravity. This fluid dissolves cellulose at once.

Celluloid Varnish (Tscheuschner).—100 parts ether alcohol, 3 parts pyrocylin, 0.2 part boracic acid, 5 parts rosin; for a wine-bottle, take 100 parts ether alcohol, 3 to 4 parts of pyrocylin, 1 part boracic acid, 25 parts of rosin and 50 parts of mineral coloring substance.

Ceresine Paper.—Saturate ordinary paper with a mixture of equal parts of stearine and tallow or ceresine. If we desire to apply a business stamp on the paper, the unsaturated paper must be allowed to dry thoroughly for 24 hours after stamping, in order to prevent smearing of the aniline color.

Color Venenum.—Corrosive preparations for removing old paint. I. 5 parts caustic lime, 1 part 40 per cent water-glass, 1 part spirits of salammoniac. II. 23 parts of water, 4 parts flour, 1 part borax, 4 parts soft soap, 11 parts caustic soda, 11 parts caustic potash. III. 2 parts soda water glass, 1 part caustic ammonia.

A new disinfectant is produced by Krönig and Paul, by mixing 45 parts by volume of concentrated hydrochloric acid with 1,600 parts of water and 500 parts of a 4 per cent permanganate of potash solution. The most obstinate germs are destroyed by this disinfectant. It discolors the skin, but the spots can be removed with the aid of a 10 per cent oxalic acid solution or a 5 per cent solution of hydrochloric acid.

Lightning Matches.—Suitable strips of paper or cardboard are perforated at one end and covered on one side with tissue paper. This makes a small chamber, that can be filled with a suitable mixture, for instance one composed of 50 parts of powdered magnesium, 40 parts of chlorate of potash, 1 part amorphous phosphorus. If we now apply to the other side of the tissue paper a suitable igniting mass, the strips thus prepared may be used as lightning matches.

Chromograph Mass.—I. 100 parts gilders' glue, 500 parts of baryta precipitate, 100 parts of dextrine, 1,000 to 1,200 parts of glycerine. The mass is stirred, while heated, until the glue and dextrine are dissolved, then cooled somewhat and poured into the tin boxes. If a sample furnished too small a number of copies, or if the layer is very difficult to wash off, more glycerine should be added. II. 100 parts of gilders' glue, 500 parts of baryta precipitate, 1,200 parts of glycerine. III. 100 parts of glue, 50 parts of glycerine, 25 parts of finest pulverized heavy spar, 375 parts of water.

Ivory with Metal and Stone Decoration.—Arms, crosses, jewel caskets, brooches, sleeve buttons and other articles of use and ornament, may be made advantageously from ivory; it is desirable, however, in order to improve the effect, to make a metal or stone insertion and then to set or mount the settings in the ivory, so that they may ornament it. In order to accomplish good settings, the ivory must be made plastic, so that it will lend itself to certain processes. For this purpose, it must be immersed for some hours in phosphoric acid, whereby its opacity also disappears. After washing in cold water, the ivory can be bent as desired into wave-like shapes, blunt-edged patterns, etc., and after it has been exposed for some time to the air, it recovers its former hardness and color. The decoration of the ivory, by means of metal and stones, varies widely; for instance, in the case of curved weapons, an edge-mounting of silver and stones is very effective, whereas in ivory crosses, inlaid incrustations, stone framelets, etc., can well be employed. Jewel cases may be decorated on the lids irregularly with precious stones set in silver (sowed, as it is called). Swelled decorative cups or goblets of ivory may be set with a narrow gold rim.—Die Goldschmiede Zeitung.

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